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## Technical Memorandum 86044

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MEASUREMENTS AND NASTRAN ANALYTICAL VALUES  
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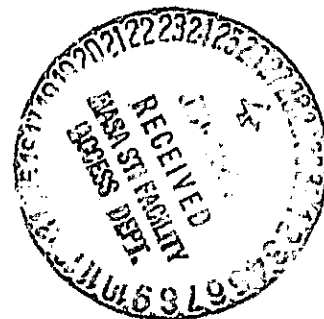
# STATISTICAL CORRELATION OF STRUCTURAL MODE SHAPES FROM TEST MEASUREMENTS AND NASTRAN ANALYTICAL VALUES

L. Purves, R. Strang, M.P. Dube, P. Alea,  
N. Ferragut, and D. Hershfild

NOVEMBER 1983

National Aeronautics and  
Space Administration

Goddard Space Flight Center  
Greenbelt, Maryland 20771



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ABSTRACT

This document describes the software and procedures of a system of programs used to generate a report of the statistical correlation between NASTRAN modal analysis results and physical test results from modal surveys. Topics discussed include a brief mathematical description of statistical correlation, a user's guide for generating a statistical correlation report, a programmer's guide describing the organization and functions of individual programs leading to a statistical correlation report, and a set of examples including complete listings of programs, and input and output data.

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## ACKNOWLEDGEMENT

The development effort that is reported in this Technical Memorandum is the result of work by a number of people.

Lloyd Purves of the Goddard Computer Aided Design Section initiated this effort with the objective of developing a more automated and complete method of comparing the results from structural testing with design predictions. Thomas Butler, formerly with Goddard and now with Butler Analyses, Inc., selected the mathematical and statistical techniques that are used in this correlation process. He also designed the approach for extracting the predicted data from the NASTRAN finite element program. Don Hershfeld of the Goddard Structural Dynamics and Electromagnetic Test Section defined the procedures and formats for recording the test data. Robert Strang of Computer Sciences Corporation designed and wrote the software for performing the statistical correlation, and for extracting and reformatting the test and predicted data. Together, Butler, Hershfeld, and Strang used this software to successfully correlate the mode shapes of a simple plate as predicted by NASTRAN and as measured by tests.

Following this initial application, the system was applied to a more complex case, that of correlating the mode shapes for a space flight experiment package, the SPARTAN-1 payload, which is expected to be carried into orbit on the Space Shuttle. This Technical Memorandum covers the results of performing that correlation. Nelson Ferragut of the Flight Section within the Goddard Special Payloads Division developed the NASTRAN model for the SPARTAN experiment; Peter Alea of the Goddard Structural Dynamics and Electromagnetic Test Section designed and managed the testing of SPARTAN payload; and Maurice Dube of Systems and Applied Sciences Corporation extended the software to handle this more complex application. M. Dube also carried out all of the computer runs to obtain the correlation coefficients, and he performed the bulk of the work in putting together this Technical Memorandum.

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# STATISTICAL CORRELATION OF STRUCTURAL MODE SHAPES FROM TEST MEASUREMENTS AND NASTRAN ANALYTICAL VALUES

## Section 1

### INTRODUCTION AND OVERVIEW

In recent years there has been a large improvement in the design of mechanical structures. The digital computer has significantly contributed to this improvement. Computer implementations of the finite element technique, in programs such as NASTRAN (NASA STRuctural ANalysis), have made it possible to predict accurately and in great detail the behavior of complex structures.

Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) have lowered the costs of creating complex and sophisticated structures. Computer Aided Testing (CAT) has allowed much more extensive testing to be performed on structures. It has appeared that relatively less attention has been paid to the computerized comparisons between analytical and test data. Since many million bits of analytical and test data can be easily created with computer techniques, it is not practical to do complete comparisons manually. The use of appropriate computer methods, some of which can be based on statistical analyses, can increase the speed and completeness with which comparisons between test and analytical data can be made.

Potentially, automated techniques can help identify whether disagreement is due to faulty test procedures or faulty modeling. Another promising long range benefit of the automated correlation of analytical and test data is that structural design can be further improved. There is presently no widely accepted and effective way of validating analytical results on real problems. Statistical comparisons with equivalent test data appear to provide an acceptable means for this validation. If this technique becomes widely used and improved, then it could gradually lead to improved analytical techniques, thus, leading in turn, to improved designs and eventually to improved structures.

The purpose of this document is to describe some recent developments, based on statistical correlation, of comparing two given sets of data. With the techniques described below, NASTRAN and several pre-processing programs place analytical results in a format in which they can be statistically compared with the test results. The STATCORR program has been developed to compile a statistical correlation report in which the engineer can easily interpret and make necessary decisions based on the statistical comparisons of the two sets of data.

In aerospace structures, it is necessary to compare structural vibration properties obtained from testing with those obtained from analysis. The most meaningful comparisons of data are those based on like vibrational modes. A test mode and an analytical mode are alike if the amplitude of the standing wave pattern is "exactly" the same at all sample points, or more realistically, if the pair of modes correlate closely.

The limited amount of experimental data and the limited access in which to install sensors at interior points are factors that constrain the points at which comparisons can be made. There is a disproportionately large number of points at which analytical data is available for comparison. The objective is to draw useful comparisons within the constraints of available data. The intent is to be able to identify the mode shapes from both of the sources; to analyze the relationship of any two mode shapes; to delineate at which frequencies the test mode and the analytical mode of a closely related pair appear; to give the locations at which two modes diverge beyond a threshold; and to isolate the greatest divergence.

The chart in Figure 1 provides a pictorial overview of the NASTRAN software system and the statistical correlation software on the GSFC Code 750 VAX-11/780 computer.

Section 2 of this document provides a brief mathematical description of the more essential quantities used in statistical analyses of data and in the STATCORR program.

Section 3 is a user's guide covering the execution of NASTRAN and the statistical correlation utility programs.

Section 4 is a programmer's guide describing the organization and functions of individual programs leading to the statistical correlation report.

Section 5 contains a set of examples, including a description of the Spartan-1 model. Also provided are complete listings of some of the input and output data.

The Appendix contains the NASTRAN input data of the SPARTAN-1 model, and an example of a statistical correlation report. Also included are the FORTRAN source code listings of STATCORR and the other preprocessing programs.

The Statistical Correlation software is part of the NEXUS CAD/CAM system at GSFC, and it is available from COSMIC. The files exist in the NEXUS\_LIB: [NEXUS,NASTRAN,STATCORR] directory, with the programs in the [.PROGRAMS] subdirectory and the demonstration files in the [.DEMO] subdirectory. The demonstrations are based on the SPARTAN-1 model (described in detail in section 5), and can be run with the help of the STATCORR.COM command procedure file. The analytical NASTRAN input data files are called: FRE.NID, FXT.NID, and ETUPLT.NID; the experimental input data files are called: FMS. . .

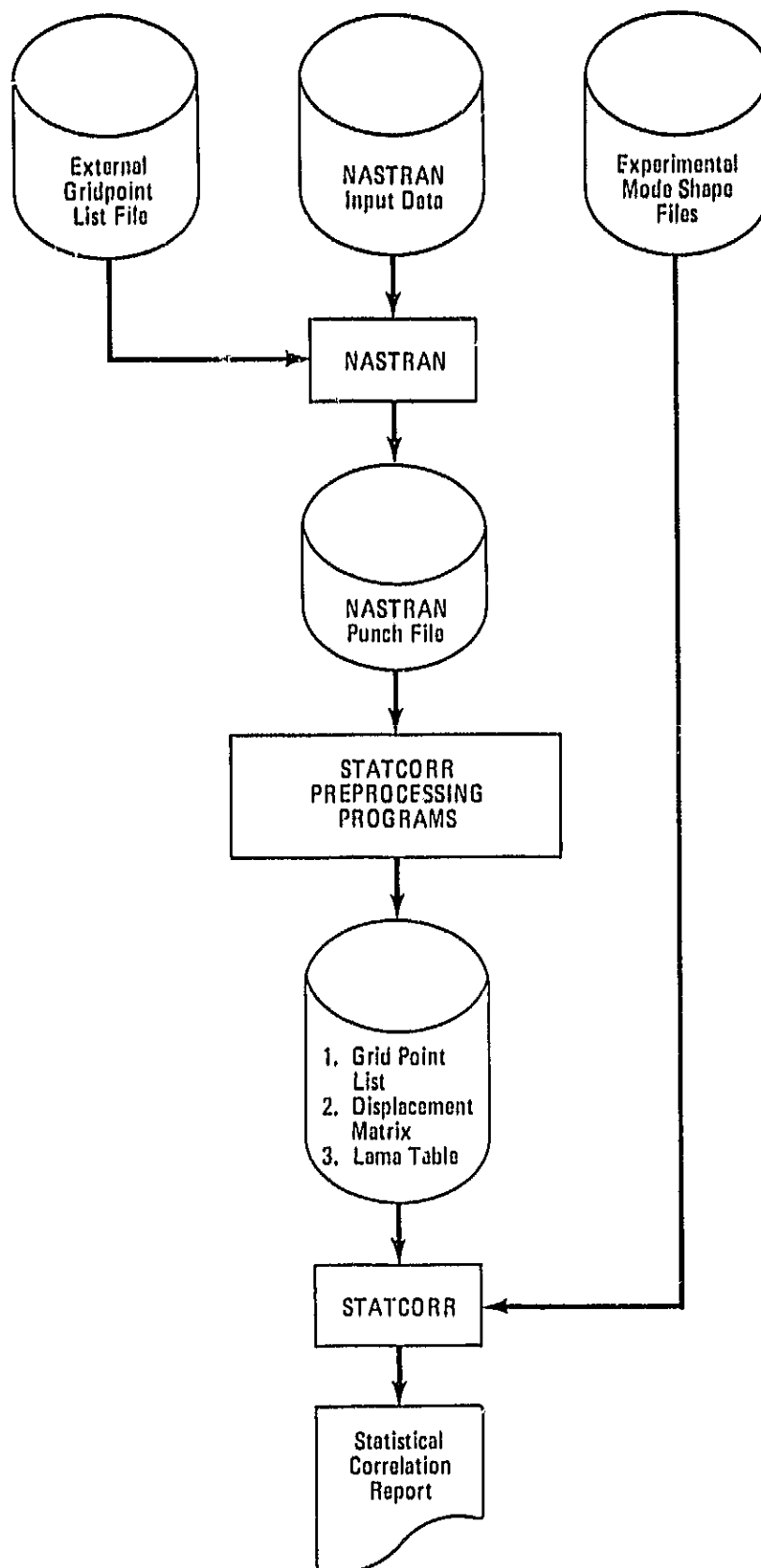


Figure 1. Data-Set Interface between NASTRAN, the Preprocessing Programs and STATCORR

## Section 2

### THEORY OF STATISTICAL CORRELATION

Static and dynamic characteristics of mechanical structures are determined both analytically and experimentally. In either case, the results of such determinations are subject to random variation. For example, analytical modes of a structure will vary because of differences in interpretation of drawings, and representations of elastic relations and mass properties. Similarly, experimental results will vary because of instrumentation errors, data recording noise, and data processing techniques. Despite these variations, it is hoped that both the analytical and experimental results will tend to correlate.

Analysis and testing results can be systematically compared, using well-established principles of statistics, particularly, the correlation coefficient. (See Freund, "Mathematical Statistics.") The criterion for deciding whether two mode shapes describe the same mode will be how close their correlation coefficient is to unity.

Some of the more important quantities used in statistical analyses are described below. The mean is defined as the first moment of a distribution about the origin. That is,

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \cdot f(x_i) = \frac{1}{n} \sum_{i=1}^n x_i \quad (1)$$

where for the purpose of this analysis, the quantity  $x_i$  is the amplitude of a vibration mode at a particular point "i". Function  $f(x)$  is the probability function for the amplitude  $x_i$ . With the probability that a vibration mode exists at each point at the time of the sample measurement, then the probability function reduces to one at each point,  $f(x_i) = 1$ . The symbol  $n$  is the total number of points in the sample where a measurement is made.

The variance is defined as the second moment of a distribution about its mean. That is,

$$\sigma_x^2 = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x}) \cdot f(x_i) = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x}) \quad (2)$$

For the purposes of this application, the RMS (root mean square) of a distribution is defined as:

$$\text{RMS} = \text{standard deviation} = \text{SQRT}(\text{variance}) = \sigma_x \quad (3)$$

Covariance is defined as the first product moment of two separate distributions about their respective means. That is,

$$\sigma_{xy} = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x}) \cdot (y_i - \bar{y}) \quad (4)$$

A quantity closely related to the covariance is the correlation coefficient,  $\rho$ . It is defined as:

$$\rho_{xy} = \frac{\sigma_{xy}}{\sigma_x \cdot \sigma_y} \quad (5)$$

The correlation coefficient is independent of any scaling of the mode shapes, and thus frees both the analyst and the experimentalist to scale data in the manner of their choice. Each set of data is scaled to its own standard deviation and both are placed on equal footing regardless of how the modal data was originally obtained. All modes in both sets are compared with each other, and the correlation coefficient is computed for every combination.

It is instructive to determine where and by how much mode shapes differ from one another. However, because of scaling, the difference between the amplitudes of two mode shapes is not significant. One method to obtain significant differences is to rescale the mode by their respective RMS values. This rescaling puts all mode shapes on an equal basis. The relative difference between the amplitudes of two mode shapes at a point is then

$$\text{Relative Difference} = \frac{x_i}{\sigma_x} - \frac{y_i}{\sigma_y} \quad (6)$$

Another method rescales one of two mode shapes to be compared so that the mean squared difference between the two mode shapes is minimized. The scaling factor for this method is:

$$C = \frac{\sum_{i=1}^n x_i y_i}{\sum_{i=1}^n x_i^2} \quad (7)$$

If the x mode shape is multiplied by this scaling factor, the mean squared difference between the x and y mode shapes will equal:

$$S = \frac{1}{n} \left( \sum_{i=1}^n y_i^2 - C^2 \cdot \sum_{i=1}^n x_i^2 \right) \quad (8)$$

The square root of the mean squared difference is called the standard difference, S. The difference between the amplitudes of the two mode shapes can now be compared to the standard difference to detect any significant variations between mode shapes. The scaled difference is defined as:

$$\text{Scaled Difference} = (Cx_i - y_i)/S \quad (9)$$

Most of the above quantities are used in the statistical correlation report, and an example of such a report is given in Appendix C. The variances, correlation coefficients, and RMS values are computed in the CORRMS subroutine of the STATCORR program. The relative and scaled differences are computed in the RMSDIFF subroutine. Further discussion on the theory of statistical correlation will be found in a future Technical Memorandum\* called "Statistical Correlation Analysis For Comparing Vibration Data From Test and Analysis," by L. R. Purves, D. J. Hershfeld, T. G. Butler, and R. F. Strong.

\*TM 86081

### Section 3

#### USER'S GUIDE

The following is a guide to aid the user in the execution of NASTRAN and the statistical correlation utility programs. The STATCORR utility program generates a statistical correlation report from results of analytical NASTRAN data and experimental test data. Also needed as input to STATCORR is an external gridpoint list, that is, a set of gridpoints governing the location and orientation of the test sensors.

The data that is entered as input into the STATCORR program must be entered according to a specific format. There are several preprocessing programs which are used to properly format this data, and they are described below.

First, one needs to process the NASTRAN analytical data. The NASTRAN input data file usually contains an Executive Control Deck, a Case Control Deck, and also a Bulk Data Deck. This file may reside on a disk or a magnetic tape. The tape may contain data from a previous NASTRAN run, and if this is the case, then the necessary files are copied from the tape to the user's disk. This tape should include the following files: a print file (EX1.PRT;1, for example), a command procedure file (EX1.COM;1), a "new problem tape" file (EX1.PTP;1), and a NASTRAN input data file (EX1.NID;1). The file, EX1.PTP;1, is the "new problem tape" of a previous NASTRAN run, but becomes an "old problem tape" for the next NASTRAN restart run.

Figure 2 shows the command procedure for assigning files in a NASTRAN restart run. The default must first be set to the user's directory in each of the following command procedure files. The first assignment is the NASTRAN print file. In the VAX system, data written to Logical Unit 6, FOR006, goes to the log file for the batch job, by default. The procedure assigns a filename to FOR006, and the NASTRAN print output is written to the assigned file rather than the batch job log file. In the next assignment, the NASTRAN old problem tape file is assigned to the Logical

Unit 8, FOR008. In the last assignment, NASTRAN writes the Bulk Data from the previous NASTRAN run to the punch file, the Logical Unit 77, FOR077. The punch file becomes the Bulk Data Deck for the NASTRAN input data of the next NASTRAN run. (This is described in more detail below.) The last step in the command file results in the execution of the NASTRANX procedure. The "EXEC" command is a global symbol defined for users of the Code 750 VAX-11/780 computer system for executing commands in the DRA0:[USRLIB.COM] directory. The following definition is used:

```
EXEC: = "@DRA0:[USRLIB.COM]COMC"
```

The COMC.COM command procedure contains the following DCL command:

```
$ @DRA0:[USRLIB.COM] 'P1' 'P2' 'P3' 'P4' 'P5' 'P6' 'P7' 'P8'
```

NASTRANX is a command procedure which may contain up to five input parameters, P1, P2, P3, P4, and P5. If any particular parameter is to be used, all the preceding parameters must also be defined by the user, but following parameters may be ignored. P1 is the user's NASTRAN input file name; in this example it would be, EX1.NID. P3 is the maximum number of NASTRAN links to execute (default = 100,000,000). In order to generate the punch file only the first link is needed. Since P3 was specified, P2, the NASTRAN executable assignment file name

```
(default = @DRA0:[USRLIB.COM] NSASSIGN),
```

must also. By specifying P2 with the word "DUMMY", the default is used.

```
EX1.COM; 1

$ SET DEF [ ]
$ ASSIGN EX1.PRT FOR006
$ ASSIGN EX1.PTP FOR008
$ ASSIGN EX1.DIC FOR077
$ EXEC NASTRANX EX1.NID DUMMY 1
$ DEASSIGN FOR006
$ DEASSIGN FOR008
$ DEASSIGN FOR077
$ EXIT
```

Figure 2. Example of a User's Command Procedure for Assigning Files in a NASTRAN Restart Run

For user's of the GSFC Code 750 VAX-11/780 computer system, the submit command for running batch jobs is given by:

```
$ SUBMIT/QUEUE=NASTRAN EX1.COM
```

The NASTRAN input data file should contain a NASTRAN card, and it is the first card in the NASTRAN data deck. (An example of a NASTRAN input data deck is given in Appendix A.) The Restart deck follows the NASTRAN and ID cards, and then followed in order by the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck. In this case, the Bulk Data is empty, but one will be generated from this run as a punch file. The only modification to be made to the NASTRAN input data file prior to the run is the ECHO card in the Case Control Deck, and this should be changed to:

```
ECHO = PUNCH
```

The job is then submitted to batch, and the resulting punch file, EX1.DIC, is appended to the NASTRAN input data, EX1.NID, as the NASTRAN Bulk Data Deck. The ENDDATA card is then shifted to the last card of the deck. The following modifications to NASTRAN Input Data file are made: the NASTRAN card along with all of the Restart cards are deleted; in the Executive Control Deck, the CHPNT YES card is deleted, the DIAG 14 card is changed to DIAG 14,21,22, and the following alter cards are added:

```
ALTER 41  
EXIT $  
ENDALTER
```

In the Case Control Deck, the ECHO card is modified to read:

```
ECHO = NONE
```

The command procedure file is also modified, and Figure 3 shows how the command procedure file should read. Several print files are generated during the NASTRAN run, and the \$EXEC CONCAT procedure concatenates different versions of files with the same filename, as in this case,

```
EX1.PRT;1, EX1.PRT;2, . . . . .
```

This job is then submitted to batch, and a concatenated print file is generated. A grid point list file must also be obtained or constructed, and it may be called GRDPT.LIS. This file is in a free-field format, and it contains a list of all of the grid points in which test sensors were located during the test. Next, the preprocessing programs are run. First, the TESETDMI program is run; it is designed to be run interactively, and it asks for the name of the NASTRAN print file and the name of the gridpoint list. A sample TESETDMI dialog is given as:

```

$ RUN TESETDMI
FILENAME OF NASTRAN PRINT FILE WITH DIAG 21: EX1.PRT
FILENAME OF MODAL SURVEY GRIDPOINT LIST: GRDPT.LIS
FILENAME FOR TESET DMI BULK DATA RECORDS: TESET.DMI
WARNING - NO INTERNAL DOF FOR GRID POINT      382-1
WARNING - NO INTERNAL DOF FOR GRID POINT      382-2
WARNING - NO INTERNAL DOF FOR GRID POINT      382-3
WARNING - NO INTERNAL DOF FOR GRID POINT      407-1
WARNING - NO INTERNAL DOF FOR GRID POINT      407-2
WARNING - NO INTERNAL DOF FOR GRID POINT      407-3
WARNING - NO INTERNAL DOF FOR GRID POINT      412-1
WARNING - NO INTERNAL DOF FOR GRID POINT      412-2
WARNING - NO INTERNAL DOF FOR GRID POINT      412-3

FORTRAN STOP - PROCESSING COMPLETED
$

```

An output file, called TESET.DMI, is generated, and this file is appended to the NASTRAN input data file. The file, TESET.DMI, contains the same list of grid points as the original file, GRDPT.LIS, but in the proper DMI format to be inserted into the NASTRAN Bulk Data Deck. The card ENDDATA is then shifted to the last card in the deck, and EX1.NID is modified: the DIAG 14,21,22 card is changed to DIAG 14, and the alter cards changed as follows:

```

ALTER 74
TABPCH LAMA, , , ./FM $
ALTER 78
PARTN PIIG, ,TESET/,PHITE, ,/ +1/1/2/2 $
OUTPUT3 PHITE,TESET/ /-1/N1=VCT/N2=DOF $
EXIT $
ENDALTER

```

The command procedure file is also modified, and Figure 4 shows how the file should read. This job is then submitted to batch, and a concatenated print file and punch file are generated. However, the user must first delete the old print files, otherwise they will be concatenated with the new ones.

```

EX1.COM;1

$ SET DEF [ ]
$ ASSIGN EX1.PRT FOR006
$ EXEC NASTRANX EX1.NID
$ EXEC CONCAT EX1.PRT
$ DEASSIGN FOR006
$ EXIT

```

Figure 3. Example of a User's Command Procedure for Assigning and Concatenating a Print File

```

EX1.COM;3

$ SET DEF [ ]
$ ASSIGN EX1.PRT FOR006
$ ASSIGN EX1.PCH FOR077
$ EXEC NASTRANX EX1.NID
$ EXEC CONCAT EX1.PRT
$ EXEC CONCAT EX1.PCH
$ DEASSIGN FOR006
$ DEASSIGN FOR077
$ EXIT

```

Figure 4. Example of a User's Command Procedure for Assigning and Concatenating a Print File and a Punch File

The following programs are then run interactively. The UNPACKDMI program asks for the name of the concatenated punch file, EX1.PCH, and also the names of two matrices, TESET and PHITE. A sample UNPACKDMI dialog is as follows:

```

$ RUN UNPACKDMI
ENTER NAME OF NEXT DMI FILE: EX1.PCH
ENTER MATRIX NAME. ("*ALL" FOR ALL MATRICES): TESET
MATRIX FILE WRITTEN WITH MROWS, NCOLS:
TESET .MTX 1656 1
DO YOU WANT ANOTHER MATRIX IN THIS FILE? (Y OR N): Y
ENTER MATRIX NAME. ("*ALL" FOR ALL MATRICES): PHITE
MATRIX FILE WRITTEN WITH MROWS, NCOLS:
PHITE .MTX 135 56
DO YOU WANT ANOTHER MATRIX IN THIS FILE? (Y OR N): N
DO YOU WANT ANOTHER FILE? (Y OR N): N
NO MORE FILES REQUESTED
$

```

Two output files are generated, TESET.MTX and PHITE.MTX. The file, PHITE.MTX, contains the mode shape displacements and it will later be an input file into the STATCORR program. The file,

TESET.MTX, is another file containing a list of test grid points, but in the wrong format. However, the GRDPTLST program is run and asks for the name of the grid point ID file, TESET.MTX, and generates the grid point list in the correct format. A sample GRDPTLST dialog is given as:

```
S RUN GRDPTLST
      ENTER GRID POINT ID MATRIX FILENAME: TESET.MTX
      ENTER GRID POINT ID OUTPUT LIST FILENAME: GRDPTF.LIS
      135 ENTRIES WRITTEN TO GRID POINT LIST
FORTRAN STOP
S
```

The output file is called GRDPTF.LIS, and it will also be an input file to the STATCORR program. Finally the LAMA program is run, and it asks for the name of the punch file, and the name of the LAMA table. A sample LAMA dialog is given as:

```
S RUN LAMA
      ENTER INPUT PUNCH FILE NAME: EX1.PCH
      ENTER NAME OF LAMA TABLE: LAMA
      PLANE 1 SYMMETRY NOT SPECIFIED
      PLANE 2 SYMMETRY NOT SPECIFIED
      PLANE 3 SYMMETRY NOT SPECIFIED
      ENTER OUTPUT MATRIX FILENAME: LAMA.TBL
FORTRAN STOP
S
```

An output file is generated, called LAMA.TBL, and this file contains the modal frequencies, masses, and stiffnesses, and it is another input entered into the STATCORR program. Therefore, the three files, LAMA.TBL, GRDPTF.LIS, and PHITE.MTX, contain all the necessary information (analytical NASTRAN data) in the proper format, and they are all entered as input into the STATCORR program.

Before the statistical correlation program can be run, the experimental data files are needed. These experimental data files usually exist on floppy disks, and the necessary files are copied to the user's disk with the help of the FLX utility of the VAX-11/780 computer system.

Finally, the STATCORR program is run. This program is designed to run interactively, as with the other preprocessing utility programs, and a sample STATCORR dialog is given on page C-1 of Appendix C. All the programs may also be run as a batch job with the help of a command procedure file. An example of a command procedure file used to run all the necessary programs from the initial input to the final output is shown in Figure 5.

STATCORR.COM; 1

```
$ SET DEF [NASCAT]
$ ASSIGN NEW,PRT FOR006
$ EXEC NASTRANX NEW,NID
$ EXEC CONCAT NEW,PRT
$
$ RUN [NASCAT.UTILITY,STATCORR] TESETDMI
NEW,PRT
GRDPT.LIS
TESET.DMI
$
$ EDIT NEW.NID
T "DIAG 14,21,22"
DEL
INSERT ;DIAG 14
T "ALTER 41"
DEL
INSERT ;ALTER 74
INSERT ;TABPCH LAMA, , , ,//FM $
INSERT ;ALTER 78
INSERT ;PARTN PHIG, , TESET/,PHITE, ,/+1/1/2/2 $
INSERT ;OUTPUT3 PHITE,TESET// -1/N1=VCT/N2=DOF $
T "ENDATA"
DEL
EXIT
$
$ EDIT ENDDATA.DAT
INSERT ;ENDDATA
EXIT
$
$ APPEND ENDDATA.DAT TESET.DMI
$ APPEND TESET.DMI NEW.NID
$
$ DEL ENDDATA.DAT;
$
$ ASSIGN NEW,PCH FOR077
$ EXEC NASTRANX NEW,NID
$ EXEC CONCAT NEW,PCH
$ EXEC CONCAT NEW,PRT
$ RUN [NASCAT.UTILITY,STATCORR] UNPACKDMI
NEW,PCH
TESET
Y
PHITE
N
N
$
```

Figure 5. Example of a User's Command Procedure to Run NASTRAN, the Pre-Processing Programs, and STATCORR as a Batch Job (Page 1 of 2)

```

$ RUN [NASCAT.UTILITY.STATCORR] LAMA
NEW.PCH
LAMA
LAMA.TBL
$
$ RUN [NASCAT.UTILITY.STATCORR] GRDPTLST
TESET.MTX
GRDPTF.LIS
$
$ ASSIGN AC2.PRT SYSS$OUTPUT
$ RUN [NASCAT.UTILITY.STATCORR] STATCORR
Y
LAMA.TBL
PHITE.MTX
GRDPTF.LIS
[NASCAT.EXPDATA] FMS001.AC2
[NASCAT.EXPDATA] FMS002.AC2
[NASCAT.EXPDATA] FMS003.AC2
[NASCAT.EXPDATA] FMS004.AC2
[NASCAT.EXPDATA] FMS005.AC2
[NASCAT.EXPDATA] FMS006.AC2
[NASCAT.EXPDATA] FMS007.AC2
[NASCAT.EXPDATA] FMS008.AC2
NONE
N
N
N
0.01
$ DELETE AC2.PRT;
$ PRA AC2.PRT
$ DEASSIGN SYSS$OUTPUT
$ DEASSIGN FOR006
$ DEASSIGN FOR077
$ EXIT

```

Figure 5. (Page 2 of 2)

## Section 4

### DESCRIPTION AND ORGANIZATION OF DATA

The following section describes the organization and functions of individual data sets and programs leading to the statistical correlation report. Consideration has been given to analytical and test data coming from various sources. The STATCORR program is operated on data independent of its source, as long as it is entered according to a specific format. During this development, the analysis was done using NASTRAN, and the tests were performed by the GSFC Environmental Test and Integration Branch.

At the outset, comparisons must be based on data gathered from identical sources. Liaison between test and analysis personnel prior to either the generation of the NASTRAN model or the instrumentation of the test article must first establish the points and component directions at which data is to be sampled. This set of locations (referred to as the TESET vector) governs the location and orientation of test sensors as well as the entries in the analytical partitioning vector.

Equally important as matching data points is matching boundary conditions. The most difficult experimental boundary to enforce is clamped; the easiest to enact is free-free. Liaison between the test engineer and the analyst helps to uncover any disparity between the test set-up and the analytical boundary conditions.

First, a list is obtained which contains the gridpoint ID's and their associated DOF components. From this list, an external gridpoint and DOF file is created by the user with all entries in list-directed (free-field) format. Entries are inserted in grid, DOF pairs, one pair for each gridpoint and DOF-component which is instrumented in the modal survey.

The internal sequencing of the gridpoints used by NASTRAN for matrix operations can be different from the analyst's original gridpoint sequencing. The partitioning vector, i.e., the TESET vector, must be organized according to internal sequencing, so therefore a correspondence between

internal and external sequencing is necessary. This is accomplished by inserting DIAG 21 and 22 cards in the Executive Control Deck, and an ALTER card to EXIT after the GP4 module. When DIAG 21 and 22 are activated, the detailed correspondence between the internal and external sequencing for the various sets is printed.

A program called TESETDMI.FOR will generate the TESET matrix in the proper DMI format, called TESET.DMI. Inputs to this program are the external gridpoint list file in free-field format and the NASTRAN print file with the DIAG 21 output. TESET.DMI is constructed in ordered pairs, the first member of which is a NASTRAN internal sequence number which corresponds to a component of a test point. The second member of the pair is a Grid Point ID number belonging to the test point. TESET.DMI is then inserted into the NASTRAN Bulk Data for use in partitioning the PHIG matrix and obtain the PHITE matrix. The PHIG matrix is the original total set of eigenvectors of order G, which is to be partitioned (reduced), to the PHITE matrix. The PHITE matrix is the reduced set of eigenvectors pertaining only to the test set of gridpoints.

In order to transfer the NASTRAN eigenvalue results into STATCORR, a set of DMAP ALTERS has to be included in the NASTRAN input deck before running the program. The DMAP module, TABPCH, delivers the modal frequencies, masses, and stiffnesses as part of the LAMA table in DTI format. The module PARTN does the partitioning of the PHIG matrix by the TESET vector, and OUTPUT3 delivers the resulting partitioned mode shapes as a single matrix called the PHITE matrix. Both the LAMA table and the PHITE matrix together with the TESET vector are printed out in a punch file.

Before inserting the LAMA table, the PHITE matrix, and the external gridpoint list file into STATCORR, they must first be extracted from the punch file and put into the proper format. A set of three preprocessing programs does this task. The LAMA program, with the name LAMA and the name of the punch file as input, searches the punch file for the LAMA table in DTI format. Once found, the LAMA table is printed in a separate file, usually called LAMA.TBL. The

UNPACKDMI program, with the names PHITE and TSET, and the name of the punch file as input, searches the punch file for the matrices PHITE and TSET in DMI format, and prints them in two separate files, usually called PHITE.MTX and TSET.MTX. The third program, GRDPTLST.FOR, with TSET.MTX as input, prints in a proper format the external gridpoint list in a file usually called GRDPTF.LIS. The three files, LAMA.TBL, PHITE.MTX, and GRDPTF.LIS are the three input files containing all the necessary analytical NASTRAN data in proper formats to be used in STATCORR.

The STATCORR program, as well as the other preprocessing programs, may be run interactively, or with the help of a user's command procedure file, they may also be run as a batch job, as shown in Figure 5. In order to compile and link all the necessary programs, one may use a command procedure file called COMPLINK.COM; 1, shown in Figure 6.

```
COMPLINK.COM; 1  
  
$ FOR 'P1'  
$ LINK 'P1'  
$ DEL 'P1'.OBJ;  
$ PURGE 'P1'.EXE
```

Figure 6. Example of a User's Command Procedure to Compile and Link a Computer Program

There exists a number of options to be run with the STATCORR program. The first is a request for a separate output print file. This print file, called the statistical correlation report, is printed by default to the system SYSSOUTPUT file. Therefore, in order to obtain a hard copy, the user must assign the SYSSOUTPUT file to a user's disk file with the help of the ASSIGN command. An example of this is given in Figure 5 at the start of the STATCORR program.

The first page of the statistical correlation report summarizes the interactive dialog. Part 2 on the following page contains a list of frequencies, masses, stiffnesses, and symmetries for the analytical modes, which were obtained from the LAMA table. However, only the first 200 modes are processed and listed, along with only the first 1000 DOFs. Next is a list of frequencies, dampings, and symmetries for the experimental modes. Note that the symmetry factors are not considered in

this document, but they will be discussed in detail in a future T.M. (See bottom of page 2-3). With this set of data, STATCORR computes the correlation coefficients and RMS values for all possible analytical/experimental pairs.

Part 3 of the statistical correlation report contains all the correlation coefficients for analytical versus experimental comparisons. Next, STATCORR determines the best experimental mode-shape match (highest correlation coefficient) for each analytical mode-shape, and also determines the best analytical mode-shape match for each experimental mode-shape. STATCORR also computes relative deviations greater than threshold for each mode. The desired threshold is a parameter which the user chooses with the default given by the value of 0.050.

Part 4 contains the analytical mode shapes and their best experimental matches. Also listed are the relative deviations greater than threshold, and scaled differences greater than threshold. Part 5 contains the experimental mode shapes and their best analytical matches.

The user may also request to have the analytical versus experimental symmetries to be considered for each mode. Finally, another option available to the user concerns the printing of the analytical and experimental mode-shape vectors.

A flowchart showing the sequence of steps from the initial NASTRAN input data to the statistical correlation report is given in Figure 7. Source code listings for the five programs are given in Appendices D to H. The NASTRAN input deck (with DIAG 21 and 22) for the SPARTAN-I model (See Section 5 for a detailed description) is shown in Appendix A; the external gridpoint list file for this example is given in Figure 14; a partial listing of the NASTRAN print file (with DIAG 21 and 22) is shown in Appendix B; a listing of the TESS matrix in DMI format is shown in Figure 15; a partial listing of the LAMA table is shown in Figure 16; the final external gridpoint listing, after it has been processed by the preprocessing programs, is shown in Figure 17; an example of an input file containing experimental data is shown in Figure 18; and an example of a statistical correlation report is shown in Appendix C.

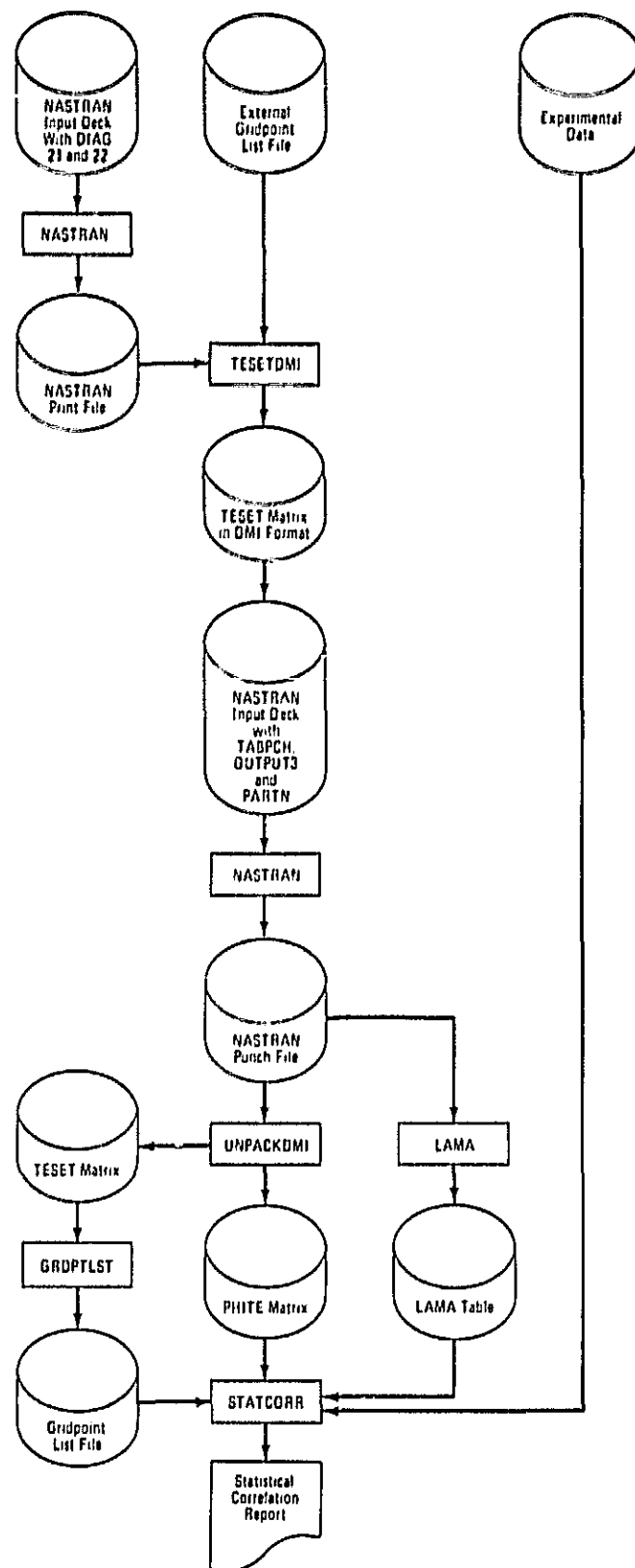


Figure 7. Flowchart Showing Sequence of Steps from the Initial Input Data to the Statistical Correlation Report

Section 5

EXAMPLES - THE SPARTAN-1 MODEL

In order to better understand the above sequence of steps in Figure 7, an example involving a realistic model will be given. The model, known as SPARTAN-1, is described in detail below. The NASTRAN Input Data listing of SPARTAN-1, with free boundary conditions and no mass mock-ups, is given in Appendix A. Included in the figures given below are complete listings of some of the input and output data to STATCORR and the other pre-processing programs. The Fortran source codes listings for these programs are given in the Appendices. Also given is an example of a statistical correlation report. Figure 8 shows a plot of the SPARTAN-1 model without the grid points.

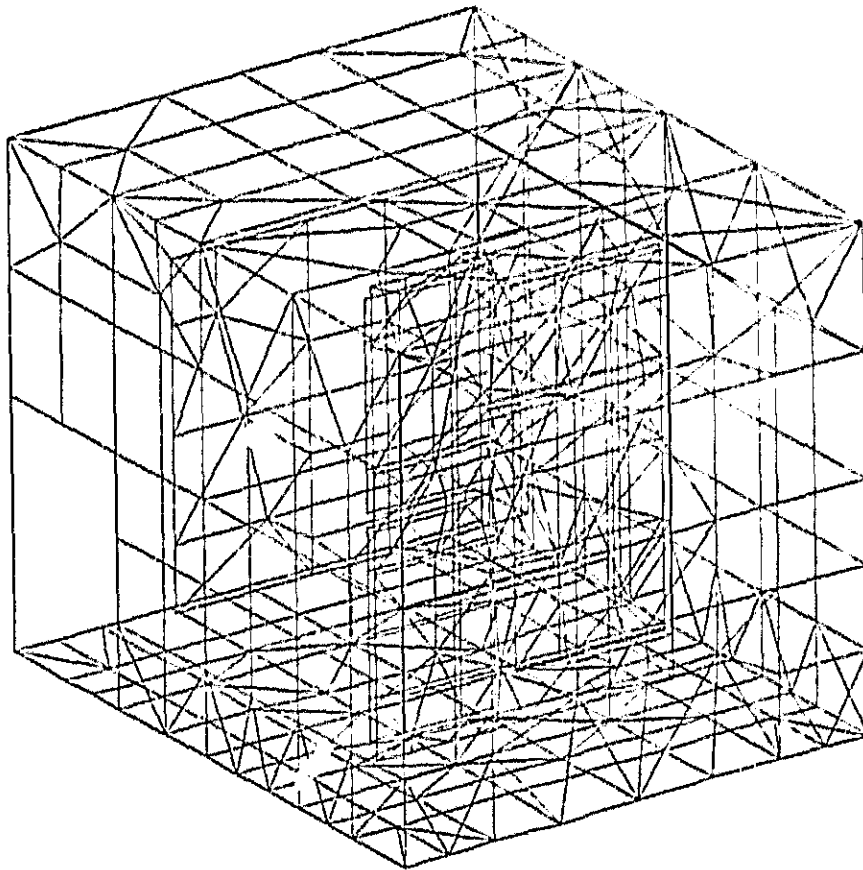


Figure 8. The Spartan-1 Model

There exists a need to verify the accuracy of dynamic finite element models derived from structures scheduled to fly on the Space Shuttle. The SPARTAN-1 payload is the first of the SPARTAN shuttle series. These SPARTAN payloads have evolved from the Sounding Rocket Experiments and can use the Shuttle environment to improve old experimental results or obtain new data not available with Sounding Rocket Technology.

The payload consists of box-like structures in which half of the volume is occupied by support equipment: electronics, the attitude control system, the tape recorder, and batteries. The other half of the volume is occupied by the experiment, which is kinematically mounted to minimize distortion.

A finite model of the structure was developed using NASTRAN. The model was built with enough details to simulate the mounting scheme of the experiment and batteries pack, and subsequently allow stress analysis of joint subassemblies. One of the requirements for payload flight certification on the shuttle is a coupled-loads analysis using modal synthesis. It is important that the finite element model be verified to provide credibility to the load analysis results.

The verification test extracted modal information from the structural test model in order to show the degree of correlation between the empirical and analytical models. This modal information includes natural frequencies, damping, and real mode shapes.

The modal survey of the structural test model was performed in three configurations:

Phase I. Flight SPARTAN frame with no mass mockups in a free boundary condition.

Phase II. Flight SPARTAN frame with no mass mockups in a fixed boundary condition.

Phase III. Engineering test unit with mass mockups in a fixed boundary condition.

The above test sequence was chosen to minimize potential errors due to boundary condition effects. The free boundary condition specified in Phase I was achieved by suspending the test item from a facility crane with shock cord. The mass mockups used in Phase III were only to simulate

the approximate weights and locations of the flight subassemblies. The modal survey consisted of exciting the structure independently at three different points and measuring the response at thirty-five locations. The approximate location of the drive and response points is shown in Figure 9. Typical test setups for Phases I, II, and III are shown in Figures 10, 11, and 12, respectively. Base-band frequency response functions (FRF) from (0-500 Hz) were calculated from the measured reference and response points. The modal information was then extracted.

Each phase of the modal survey resulted in about 15-26 real modes. A statistical correlation was performed on these mode shapes using the STATCORR program. As an example of the results, consider the first mode of vibration for each Phase (see Figure 13). It can be seen from the results shown in the figure that there is a high degree of correlation between the analytical and empirical mode shapes. Note that the correlation coefficient for Phases II and III is negative which indicates a 180-degree phase reversal for these mode shapes. Also observe the fact that even though the variations in the natural frequencies occur, such as a 20% frequency shift in the Phase II mode, the mode shapes are still well correlated.

In general, for this series of tests, the lower-order modes correlate to a higher degree than the high-order modes. This could possibly be attributed to modal density observed and thus poor modal information.

In the NEXUS\_LIB:[NEXUS.NASTRAN.STATCORR.DEMO] directory of NEXUS, there exists the demonstrations files using the SPARTAN-1 model as the prime example. Included are NASTRAN input data files and experimental data files for the SPARTAN-1, along with the STATCORR.COM command procedure file to run the statistical correlation demonstration.

DSP-I MODAL SURVEY MODEL

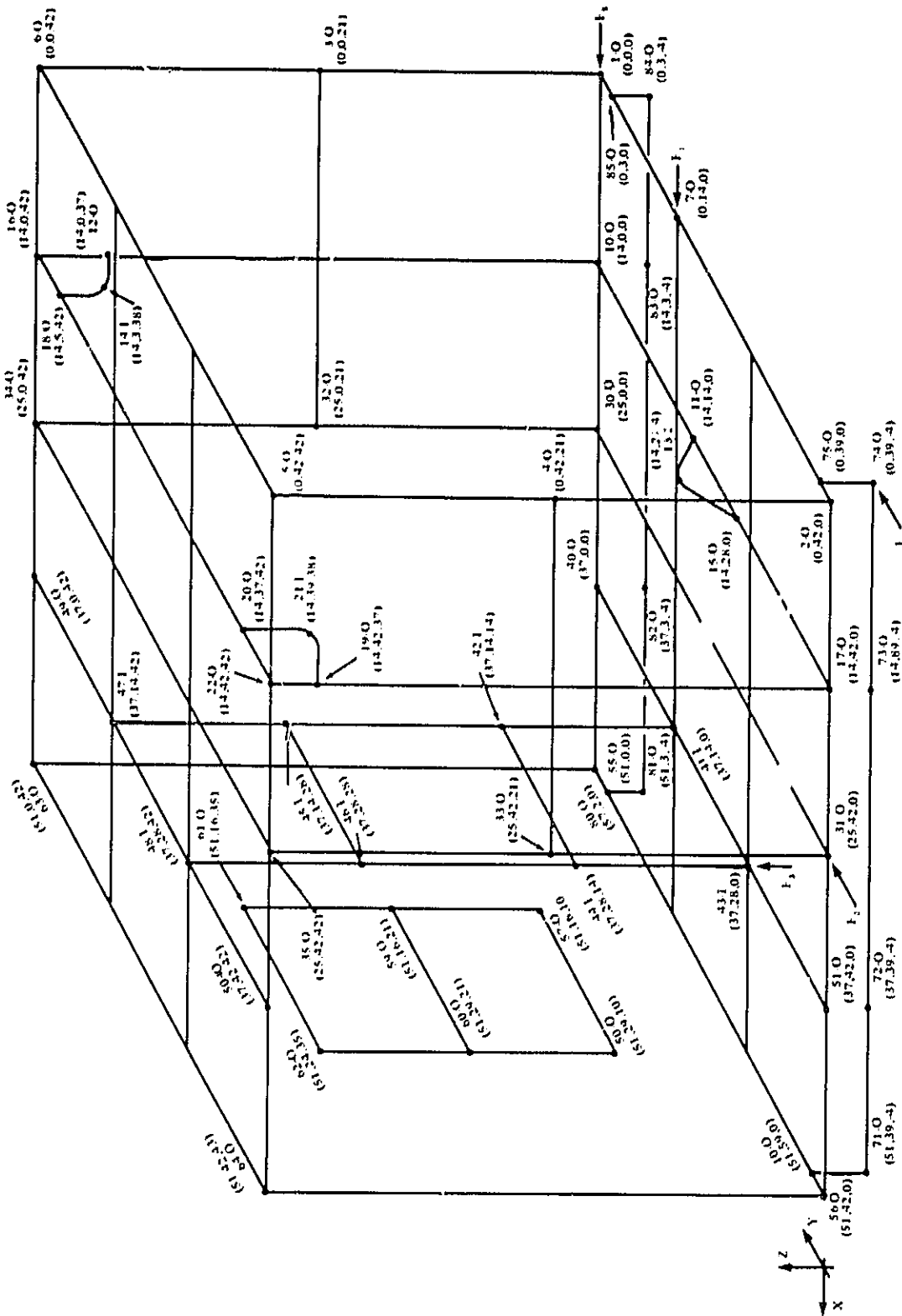


Figure 9. Modal Survey Model with Drive and Response Points (Page 1 of 2)

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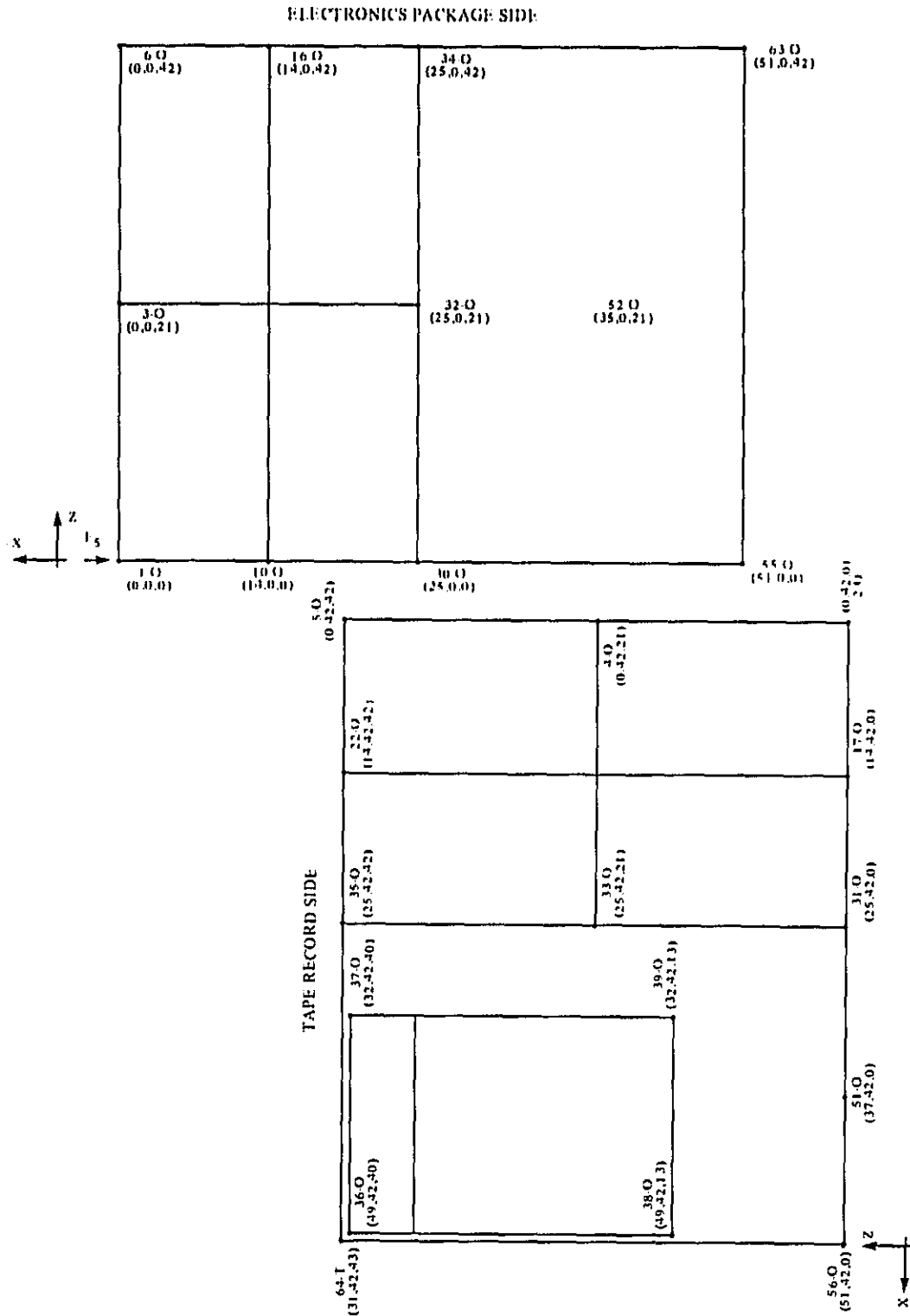


Figure 9. Modal Survey Model with Drive and Response Points (Page 2 of 2)

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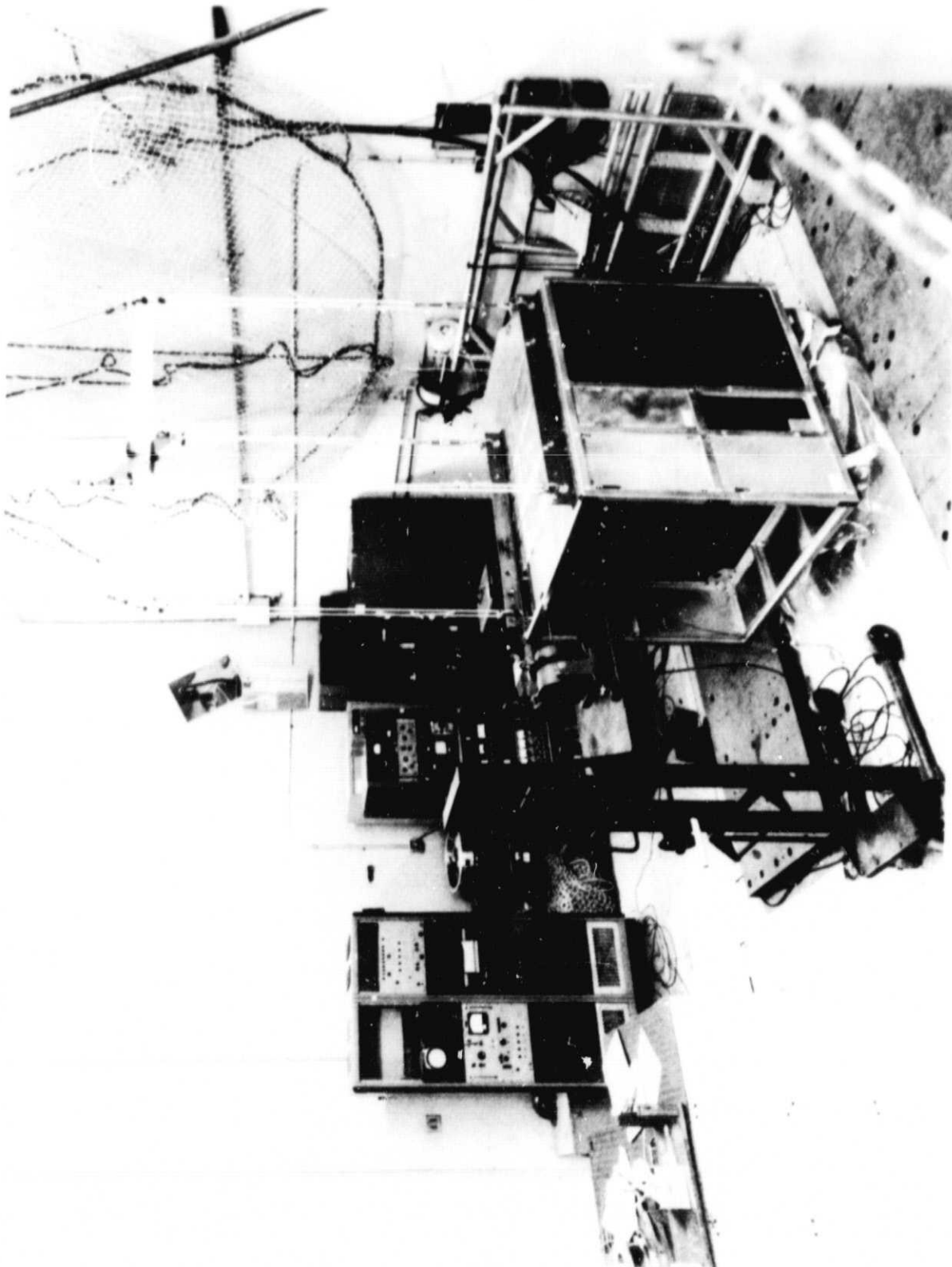


Figure 10. Phase I of the Spartan-I Model

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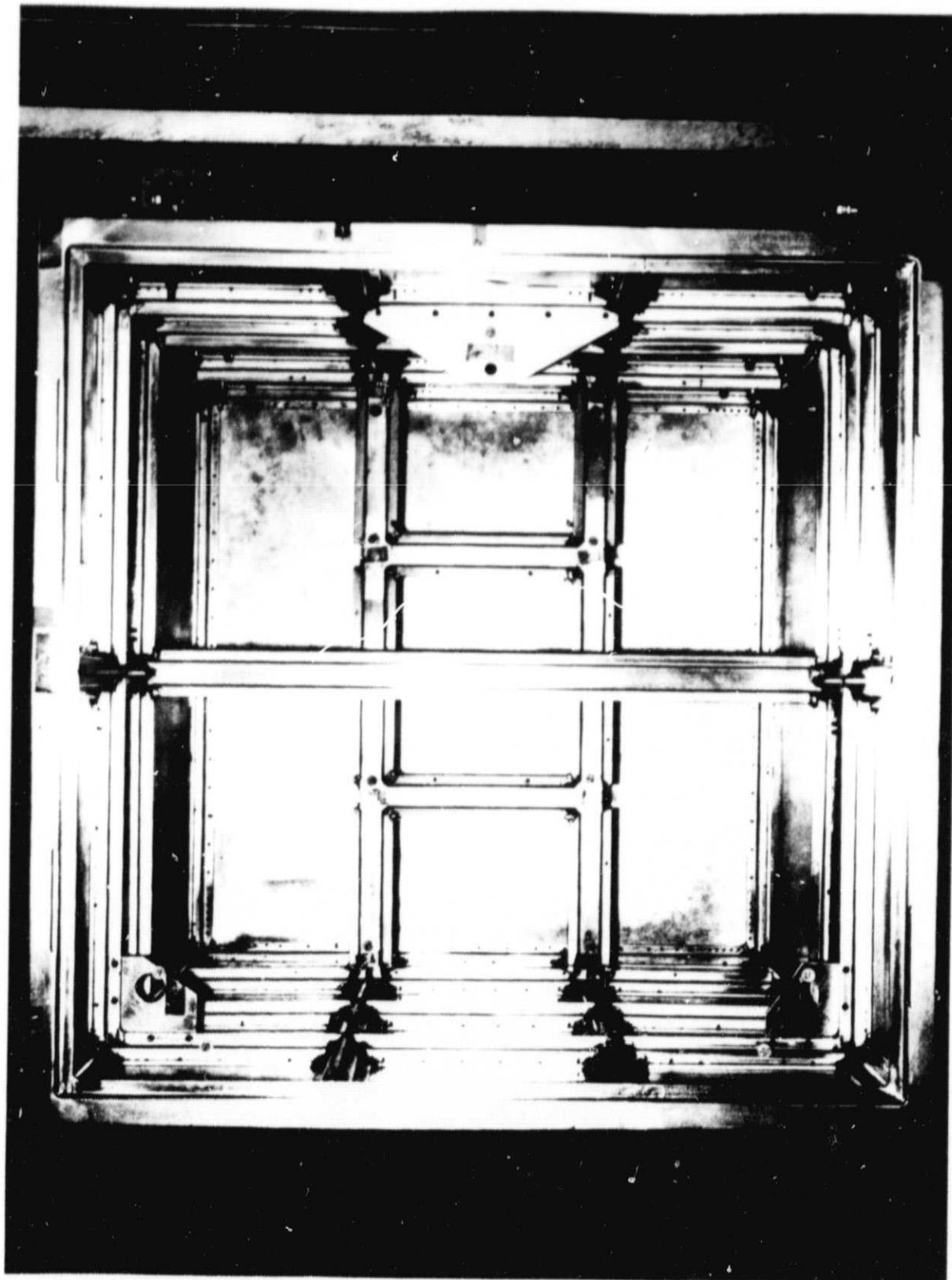


Figure 11. Phase II of the Spartan-I Model

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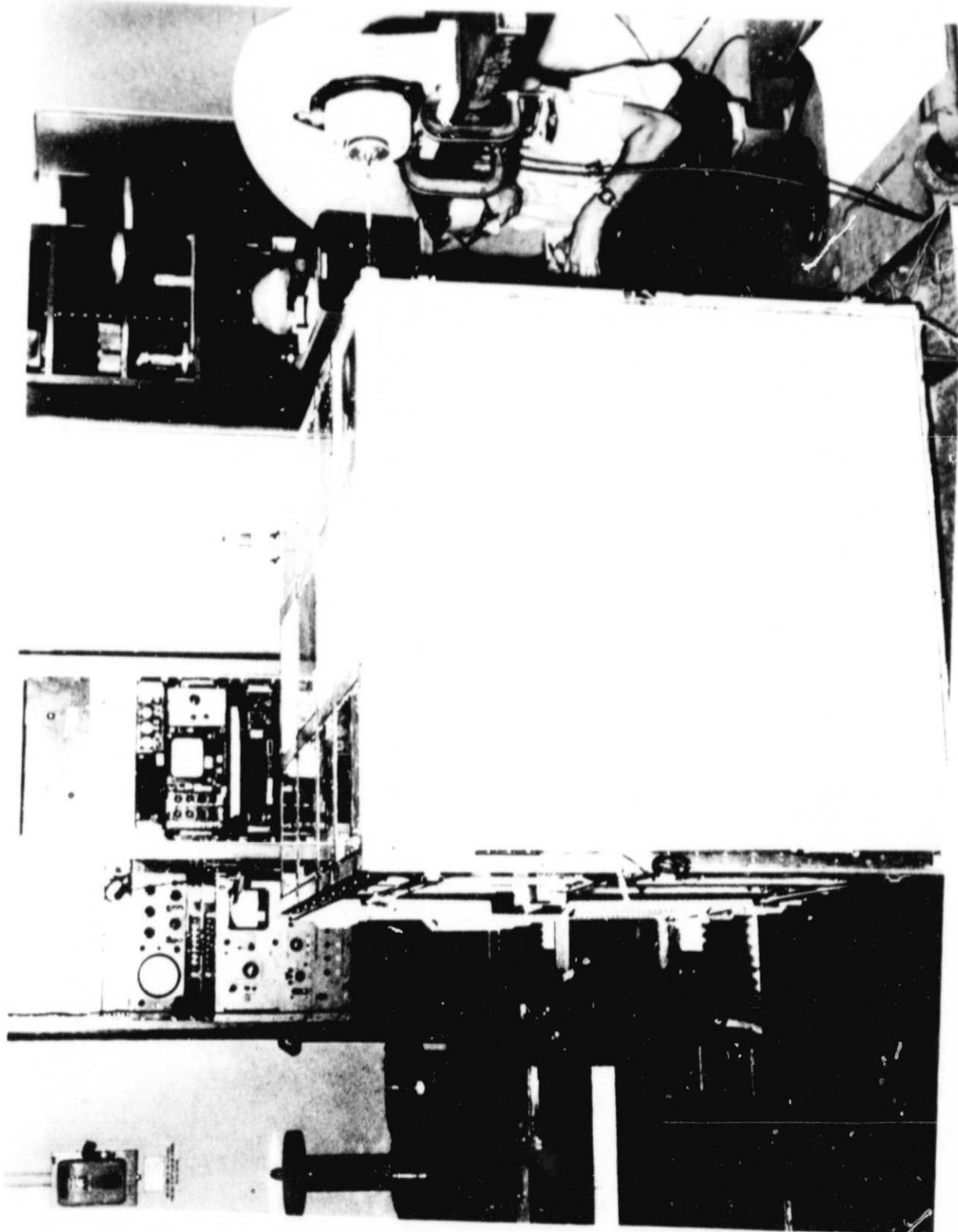
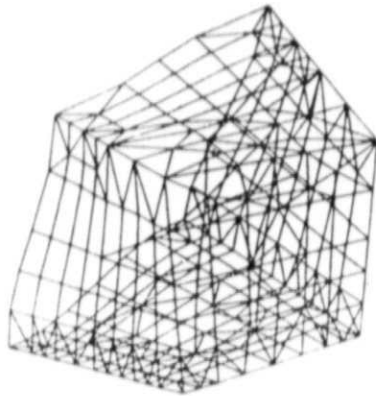


Figure 12. Phase III of the Spartan-1 Model

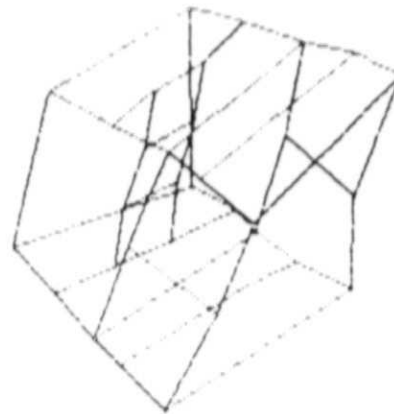
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ANALYTICAL



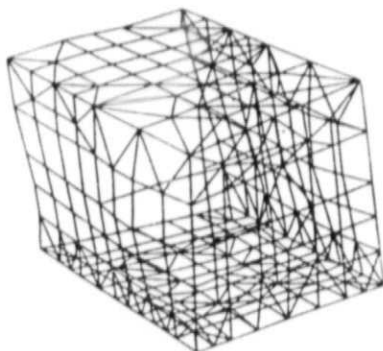
Phase I, 40.9 Hz

EMPIRICAL

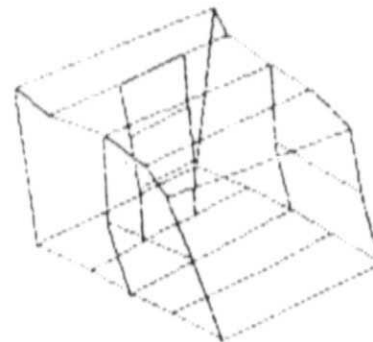


Phase I, 38.4 Hz

$$\rho = 0.941$$

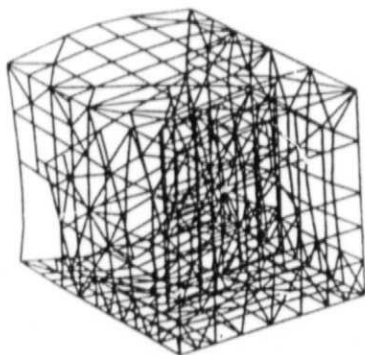


Phase II, 47.8 Hz

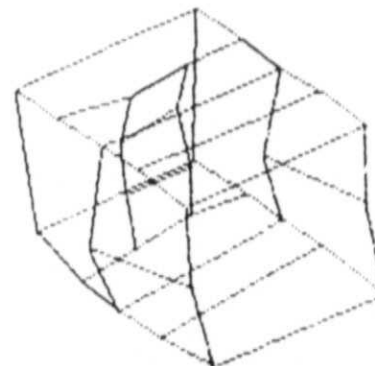


Phase II, 38.7 Hz

$$\rho = -0.950$$



Phase III, 27.8 Hz



Phase III, 26.8 Hz

$$\rho = -0.862$$

Figure 13. Analytical Versus Empirical Mode Shapes

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GRDPT.LIS;1

105,1	105,2	105,3
12,1	12,2	12,3
212,1	212,2	212,3
181,1	181,2	181,3
106,1	106,2	106,3
148,1	148,2	148,3
102,1	102,2	102,3
66,1	66,2	66,3
231,1	231,2	231,3
382,1	382,2	382,3
412,1	412,2	412,3
44,1	44,2	44,3
150,1	150,2	150,3
9,1	9,2	9,3
145,1	145,2	145,3
192,1	192,2	192,3
114,1	114,2	114,3
407,1	407,2	407,3
108,1	108,2	108,3
100,1	100,2	100,3
7,1	7,2	7,3
216,1	216,2	216,3
177,1	177,2	177,3
152,1	152,2	152,3
110,1	110,2	110,3
97,1	97,2	97,3
62,1	62,2	62,3
264,1	264,2	264,3
40,1	40,2	40,3
261,1	261,2	261,3
272,1	272,2	272,3
269,1	269,2	269,3
141,1	141,2	141,3
123,1	123,2	123,3
153,1	153,2	153,3
111,1	111,2	111,3
4,1	4,2	4,3
94,1	94,2	94,3
1,1	1,2	1,3
154,1	154,2	154,3
112,1	112,2	112,3
237,1	237,2	237,3
234,1	234,2	234,3
245,1	245,2	245,3
244,1	244,2	244,3
257,1	257,2	257,3
255,1	255,2	255,3
155,1	155,2	155,3

Figure 14. External Gridpoint Listing in Field-Free Format

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TESET.DMI:1									
DMI	TESET	0	2	1	1	2	1	1656	1
DMI	TESET	1	1	1	1	1	1	3	114.3+TE00001
+TE00001	19	108.1	20	108.2	114.1	21	114.2	97	123.1+TE00002
+TE00002	98	123.2	99	123.3	108.2	109	108.3	110	106.2+TE00003
+TE00003	111	106.3	115	112.1	123.3	116	106.1	117	112.3+TE00004
+TE00004	127	192.1	128	192.2	112.1	129	112.2	139	110.1+TE00005
+TE00005	140	110.2	141	110.3	192.2	145	192.3	146	111.2+TE00006
+TE00006	147	111.3	205	141.1	110.3	145	111.1	207	141.3+TE00007
+TE00007	211	145.1	212	145.2	141.1	206	141.2	367	150.1+TE00008
+TE00008	368	150.2	369	150.3	145.2	213	145.3	386	269.2+TE00009
+TE00009	387	269.3	391	272.1	150.3	385	269.1	393	272.3+TE00010
+TE00010	397	255.1	398	255.2	272.1	392	272.2	409	257.1+TE00011
+TE00011	410	257.2	411	257.3	255.2	399	255.3	452	181.2+TE00012
+TE00012	453	181.3	475	177.1	257.3	451	181.1	477	177.3+TE00013
+TE00013	493	148.1	494	148.2	177.1	476	177.2	499	154.1+TE00014
+TE00014	500	154.2	501	154.3	148.2	495	148.3	512	153.2+TE00015
+TE00015	513	153.3	523	152.1	154.3	511	153.1	525	152.3+TE00016
+TE00016	529	231.1	530	231.2	152.1	524	152.2	589	244.1+TE00017
+TE00017	590	244.2	591	244.3	231.2	531	231.3	602	234.2+TE00018
+TE00018	603	234.3	715	155.1	244.3	601	234.1	717	155.3+TE00019
+TE00019	727	1.1	728	1.2	155.1	716	155.2	775	245.1+TE00020
+TE00020	776	245.2	777	245.3	1.2	729	1.3	866	212.2+TE00021
+TE00021	867	212.3	889	216.1	245.3	865	212.1	891	216.3+TE00022
+TE00022	937	261.1	938	261.2	216.1	890	216.2	955	264.1+TE00023
+TE00023	956	264.2	957	264.3	261.2	939	261.3	1028	4.2+TE00024
+TE00024	1029	4.3	1039	12.1	264.3	1027	4.1	1041	12.3+TE00025
+TE00025	1069	9.1	1070	9.2	12.1	1040	12.2	1075	7.1+TE00026
+TE00026	1076	7.2	1077	7.3	9.2	1071	9.3	1190	97.2+TE00027
+TE00027	1191	97.3	1219	237.1	7.3	1189	97.1	1221	237.3+TE00028
+TE00028	1231	94.1	1232	94.2	237.1	1220	237.2	1315	105.1+TE00029
+TE00029	1316	105.2	1317	105.3	94.2	1233	94.3	1334	40.2+TE00030
+TE00030	1335	40.3	1351	62.1	105.3	1333	40.1	1353	2.3+TE00031
+TE00031	1447	102.1	1448	102.2	62.1	1352	62.2	1453	100.1+TE00032
+TE00032	1454	100.2	1455	100.3	102.2	1449	102.3	1550	44.2+TE00033
+TE00033	1551	44.3	1651	66.1	100.3	1549	44.1	1653	66.3

Figure 15. Listing of the TESET Matrix in DMI Format

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LAMA.TBL;1

LAMA	193	6
0.00000000E+00		
0.00000000E+00		
0.00000000E+00		
0.00000000E+00		
0.00000000E+00		
0.00000000E+00		
0.00000000E+00		
4.09620018E+01		
8.67981339E+01		
8.90685120E+01		
9.94205856E+01		
1.27756042E+02		
1.34907944E+02		
1.42572708E+02		
1.50033951E+02		
1.51256454E+02		
1.62937897E+02		
1.66910095E+02		
1.71395691E+02		
1.74670532E+02		
2.12637375E+02		
2.15316406E+02		
2.25123245E+02		
2.30611511E+02		
2.32908356E+02		
2.33731552E+02		
2.39917892E+02		
2.44069534E+02		
2.55830124E+02		
2.65958801E+02		
2.76783447E+02		
2.78470520E+02		
2.87401855E+02		
2.95211243E+02		
3.08831482E+02		
3.22150085E+02		
3.32467621E+02		
3.40402924E+02		
3.50125061E+02		
3.60949066E+02		
3.94879242E+02		
4.01737518E+02		
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Figure 16. Partial Listing of the LAMA Table

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GRDPTF.LIS;1

114-1	1
114-2	2
114-3	3
108-1	19
108-2	20
108-3	21
123-1	97
123-2	98
123-3	99
106-1	109
106-2	110
106-3	111
112-1	115
112-2	116
112-3	117
192-1	127
192-2	128
192-3	129
110-1	139
110-2	140
110-3	141
111-1	145
111-2	146
111-3	147
141-1	205
141-2	206
141-3	207
145-1	211
145-2	212
145-3	213
150-1	367
150-2	368
150-3	369
269-1	385
269-2	386
269-3	387
272-1	391
272-2	392
272-3	393
255-1	397
255-2	398
255-3	399
257-1	409
257-2	410

Figure 17. The Final External Gridpoint Listing to be  
Entered into the STATCORR Program (Page 1 of 3)

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264-1	955
264-2	956
264-3	957
4-1	1027
4-2	1028
4-3	1029
12-1	1039
12-2	1040
12-3	1041
9-1	1069
9-2	1070
9-3	1071
7-1	1075
7-2	1076
7-3	1077
97-1	1189
97-2	1190
97-3	1191
237-1	1219
237-2	1220
237-3	1221
94-1	1231
94-2	1232
94-3	1233
105-1	1315
105-2	1316
105-3	1317
40-1	1333
40-2	1334
40-3	1335
62-1	1351
62-2	1352
62-3	1353
102-1	1447
102-2	1448
102-3	1449
100-1	1453
100-2	1454
100-3	1455
44-1	1549
44-2	1550
44-3	1551
66-1	1651
66-2	1652
66-3	1653

Figure 17. (Page 2 of 3)

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257-3	411
181-1	451
181-2	452
181-3	453
177-1	475
177-2	476
177-3	477
148-1	493
148-2	494
148-3	495
154-1	499
154-2	500
154-3	501
153-1	511
153-2	512
153-3	513
152-1	523
152-2	524
152-3	525
231-1	529
231-2	530
231-3	531
244-1	589
244-2	590
244-3	591
234-1	601
234-2	602
234-3	603
155-1	715
155-2	716
155-3	717
1-1	727
1-2	728
1-3	729
245-1	775
245-2	776
245-3	777
212-1	865
212-2	866
212-3	867
216-1	889
216-2	890
216-3	891
261-1	937
261-2	938
261-3	939

Figure 17. (Page 3 of 3)

ORIGINAL PAGE IS  
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FMS001.AC2;1

```
69.11099
1.1128000E-02
  0      0      0
236      1 -3.6037002E-02
234      1 -3.8017001E-02
245      1 -6.5154999E-02
244      1 -5.7073999E-02
257      1 -2.9363001E-02
255      1 -2.5717000E-02
```

Figure 18. Example of an Input File Containing Experimental Data

ORIGINAL PAGE IS  
OF POOR QUALITY

APPENDIX A. LISTING OF THE NASTRAN INPUT DATA (WITH DIAG 21 AND 22)  
FOR THE SPARTAN-1 MODEL

```

ID DSPPLT,FREE
APP DISP
SOL 3,0
TIME 1500
DIAG 14,21,22
ALTER 41
EXIT $
ENDALTER
CEND
TITLE = ----- DSP ANALYSIS -----
SUBTITLE = FREE-FREE MODES
SPC = 1500
METHOD = 100
ECHO = NONE
OUTPUT
MAXLINES = 1000000
LINE = 60
VECTOR = ALL
BEGIN BULK
ASET1 1 234 236 244 245 255 257
ASET1 2 156 158 174 175 176 183 185
ASET1 2 177 179
ASET1 2 199 201 217 218 219 226 228
ASET1 2 214 216
ASET1 3 40 42 44
ASET1 3 62 64 66
ASET1 3 119 121
ASET1 3 137 139
ASET1 123 1 4 7 9 12 15 19
ASET1 123 21 28 37 47
ASET1 123 51 55 59 69
ASET1 123 73 84 88 90 94 97 100
ASET1 123 102 105 106 108 110 111
ASET1 123 112 116 117 123 125
ASET1 123 132 135 141 143 147
ASET1 123 148 150 152 153 154 173
ASET1 123 181 220 261 264
ASET1 123 269 272 376 377
CBAR 1 101 1 2 0.0 -1. 1. 1 +1
+1 0. -.6212 .6212 0. -.6212 .6212
CBAR 2 101 2 3 0.0 -1. 1. 1 +2
+2 0. -.6212 .6212 0. -.6212 .6212
CBAR 3 101 3 4 0.0 -1. 1. 1 +3
+3 0. -.6212 .6212 0. -.6212 .6212
CBAR 4 101 4 5 0.0 -1. 1. 1 +4
+4 0. -.6212 .6212 0. -.6212 .6212
CBAR 5 101 5 6 0.0 -1. 1. 1 +5
+5 0. -.6212 .6212 0. -.6212 .6212

```

ORIGINAL PART 17  
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CBAR	6	101	6	7	0.0	-1.	1.	1	
+6			0.	-.6212	.6212	0.	1.	.6212	+6
CBAR	7	101	7	8	0.0	-1.	1.	1	
+7			0.	-.6212	.6212	0.	1.	.6212	+7
CBAR	8	101	8	9	0.0	-1.	1.	1	
+8			0.	-.6212	.6212	0.	1.	.6212	+8
CBAR	9	101	9	10	0.0	-1.	1.	1	
+9			0.	-.6212	.6212	0.	1.	.6212	+9
CBAR	10	101	10	11	0.0	-1.	1.	1	
+10			0.	-.6212	.6212	0.	1.	.6212	+10
CBAR	11	101	11	12	0.0	-1.	1.	1	
+11			0.	-.6212	.6212	0.	1.	.6212	+11
CBAR	12	101	21	36	1.	0.0	1.	1	
+12			.6212	0.	.6212	.6212	0.	.6212	+12
CBAR	13	101	36	47	1.	0.0	1.	1	
+13			.6212	0.	.6212	.6212	0.	.6212	+13
CBAR	14	101	47	58	1.	0.0	1.	1	
+14			.6212	0.	.6212	.6212	0.	.6212	+14
CBAR	15	101	58	69	1.	0.0	1.	1	
+15			.6212	0.	.6212	.6212	0.	.6212	+15
CBAR	16	101	69	81	1.	0.0	1.	1	
+16			.6212	0.	.6212	.6212	0.	.6212	+16
CBAR	17	101	81	90	1.	0.0	1.	1	
+17			.6212	0.	.6212	.6212	0.	.6212	+17
CBAR	18	101	105	104	0.0	1.	1.	1	
+18			0.	.6212	.6212	0.	.6212	.6212	+18
CBAR	19	101	104	103	0.0	1.	1.	1	
+19			0.	.6212	.6212	0.	.6212	.6212	+19
CBAR	20	101	103	102	0.0	1.	1.	1	
+20			0.	.6212	.6212	0.	.6212	.6212	+20
CBAR	21	101	102	101	0.0	1.	1.	1	
+21			0.	.6212	.6212	0.	.6212	.6212	+21
CBAR	22	101	101	100	0.0	1.	1.	1	
+22			0.	.6212	.6212	0.	.6212	.6212	+22
CBAR	23	101	100	99	0.0	1.	1.	1	
+23			0.	.6212	.6212	0.	.6212	.6212	+23
CBAR	24	101	99	98	0.0	1.	1.	1	
+24			0.	.6212	.6212	0.	.6212	.6212	+24
CBAR	25	101	98	97	0.0	1.	1.	1	
+25			0.	.6212	.6212	0.	.6212	.6212	+25
CBAR	26	101	97	96	0.0	1.	1.	1	
+26			0.	.6212	.6212	0.	.6212	.6212	+26
CBAR	27	101	96	95	0.0	1.	1.	1	
+27			0.	.6212	.6212	0.	.6212	.6212	+27
CBAR	28	101	95	94	0.0	1.	1.	1	
+28			0.	.6212	.6212	0.	.6212	.6212	+28
CBAR	29	101	84	70	-1.	0.0	1.	1	
+29			-.6212	0.	.6212	-.6212	0.	.6212	+29
CBAR	30	101	70	59	-1.	0.0	1.	1	
+30			-.6212	0.	.6212	-.6212	0.	.6212	+30
CBAR	31	101	59	48	-1.	0.0	1.	1	
+31			-.6212	0.	.6212	-.6212	0.	.6212	+31

ORIGINAL PAGE IS  
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CBAR	32	101	48	37	-1.	0.0	1.	1	+32
+32			-.6212	0.	.6212	-.6212	0.	.6212	
CBAR	33	101	37	25	-1.	0.0	1.	1	+33
+33			-.6212	0.	.6212	-.6212	0.	.6212	
CBAR	34	101	15	1	-1.	0.0	1.	1	+34
+34			-.6212	0.	.6212	-.6212	0.	.6212	
CBAR	35	102	37	38	0.0	0.0	1.	1	+35
+35			0.	0.	.5906	0.	0.	.5906	
CBAR	36	102	38	39	0.0	0.0	1.	1	+36
+36			0.	0.	.5906	0.	0.	.5906	
CBAR	37	102	39	40	0.0	0.0	1.	1	+37
+37			0.	0.	.5906	0.	0.	.5906	
CBAR	38	102	40	41	0.0	0.0	1.	1	+38
+38			0.	0.	.5906	0.	0.	.5906	
CBAR	39	102	41	42	0.0	0.0	1.	1	+39
+39			0.	0.	.5906	0.	0.	.5906	
CBAR	40	102	42	43	0.0	0.0	1.	1	+40
+40			0.	0.	.5906	0.	0.	.5906	
CBAR	41	102	43	44	0.0	0.0	1.	1	+41
+41			0.	0.	.5906	0.	0.	.5906	
CBAR	42	102	44	45	0.0	0.0	1.	1	+42
+42			0.	0.	.5906	0.	0.	.5906	
CBAR	43	102	45	46	0.0	0.0	1.	1	+43
+43			0.	0.	.5906	0.	0.	.5906	
CBAR	44	102	46	47	0.0	0.0	1.	1	+44
+44			0.	0.	.5906	0.	0.	.5906	
CBAR	45	102	59	60	0.0	0.0	1.	1	+45
+45			0.	0.	.5906	0.	0.	.5906	
CBAR	46	102	60	61	0.0	0.0	1.	1	+46
+46			0.	0.	.5906	0.	0.	.5906	
CBAR	47	102	61	62	0.0	0.0	1.	1	+47
+47			0.	0.	.5906	0.	0.	.5906	
CBAR	48	102	62	63	0.0	0.0	1.	1	+48
+48			0.	0.	.5906	0.	0.	.5906	
CBAR	49	102	63	64	0.0	0.0	1.	1	+49
+49			0.	0.	.5906	0.	0.	.5906	
CBAR	50	102	64	65	0.0	0.0	1.	1	+50
+50			0.	0.	.5906	0.	0.	.5906	
CBAR	51	102	65	66	0.0	0.0	1.	1	+51
+51			0.	0.	.5906	0.	0.	.5906	
CBAR	52	102	66	67	0.0	0.0	1.	1	+52
+52			0.	0.	.5906	0.	0.	.5906	
CBAR	53	102	67	68	0.0	0.0	1.	1	+53
+53			0.	0.	.5906	0.	0.	.5906	
CBAR	54	102	68	69	0.0	0.0	1.	1	+54
+54			0.	0.	.5906	0.	0.	.5906	
CBAR	55	102	4	16	0.0	0.0	1.	1	+55
+55			0.	0.	.5906	0.	0.	.5906	
CBAR	56	102	16	28	0.0	0.0	1.	1	+56
+56			0.	0.	.5906	0.	0.	.5906	
CBAR	57	102	28	40	0.0	0.0	1.	1	+57
+57			0.	0.	.5906	0.	0.	.5906	

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OF POOR QUALITY

CBAR	58	102	40	51	0.0	0.0	1.	1	+58
+58			0.	0.	.5906	0.	0.	.5906	
CBAR	59	102	51	62	0.0	0.0	1.	1	+59
+59			0.	0.	.5906	0.	0.	.5906	
CBAR	60	102	62	73	0.0	0.0	1.	1	+60
+60			0.	0.	.5906	0.	0.	.5906	
CBAR	61	102	73	85	0.0	0.0	1.	1	+61
+61			0.	0.	.5906	0.	0.	.5906	
CBAR	62	102	85	97	0.0	0.0	1.	1	+62
+62			0.	0.	.5906	0.	0.	.5906	
CBAR	63	102	7	19	0.0	0.0	1.	1	+63
+63			0.	0.	.5906	0.	0.	.5906	
CBAR	64	102	19	31	0.0	0.0	1.	1	+64
+64			0.	0.	.5906	0.	0.	.5906	
CBAR	65	102	31	42	0.0	0.0	1.	1	+65
+65			0.	0.	.5906	0.	0.	.5906	
CBAR	66	102	42	53	0.0	0.0	1.	1	+66
+66			0.	0.	.5906	0.	0.	.5906	
CBAR	67	102	53	64	0.0	0.0	1.	1	+67
+67			0.	0.	.5906	0.	0.	.5906	
CBAR	68	102	64	76	0.0	0.0	1.	1	+68
+68			0.	0.	.5906	0.	0.	.5906	
CBAR	69	102	76	88	0.0	0.0	1.	1	+69
+69			0.	0.	.5906	0.	0.	.5906	
CBAR	70	102	88	100	0.0	0.0	1.	1	+70
+70			0.	0.	.5906	0.	0.	.5906	
CBAR	71	102	9	22	0.0	0.0	1.	1	+71
+71			0.	0.	.5906	0.	0.	.5906	
CBAR	72	102	22	33	0.0	0.0	1.	1	+72
+72			0.	0.	.5906	0.	0.	.5906	
CBAR	73	102	33	44	0.0	0.0	1.	1	+73
+73			0.	0.	.5906	0.	0.	.5906	
CBAR	74	102	44	55	0.0	0.0	1.	1	+74
+74			0.	0.	.5906	0.	0.	.5906	
CBAR	75	102	55	66	0.0	0.0	1.	1	+75
+75			0.	0.	.5906	0.	0.	.5906	
CBAR	76	102	66	78	0.0	0.0	1.	1	+76
+76			0.	0.	.5906	0.	0.	.5906	
CBAR	77	102	78	91	0.0	0.0	1.	1	+77
+77			0.	0.	.5906	0.	0.	.5906	
CBAR	78	102	91	102	0.0	0.0	1.	1	+78
+78			0.	0.	.5906	0.	0.	.5906	
CBAR	79	101	25	15	-1.0	0.0	1.	1	+79
+79			-.6212	0.	.6212	-.6212	0.	.6212	
CBAR	80	103	15	16	0.0	0.0	-1.	1	+80
+80			0.	0.	-1.627	0.	0.	-1.627	
CBAR	82	103	16	19	0.0	0.0	-1.	1	+82
+82			0.	0.	-1.627	0.	0.	-1.627	
CBAR	84	103	19	22	0.0	0.0	-1.	1	+84
+84			0.	0.	-1.627	0.	0.	-1.627	
CBAR	85	103	22	21	0.0	0.0	-1.	1	+85
+85			0.	0.	-1.627	0.	0.	-1.627	

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OF POOR QUALITY

CBAR	86	101	12	21	1.	0.0	1.	1	
+86			.6212	0.	0.6212	.6212	0.	0.6212	+86
CBAR	87	101	94	84	-1.	0.0	1.	1	
+87			-.6212	0.	.6212	-.6212	0.	.6212	+87
CBAR	88	103	84	88	0.0	0.0	-1.	1	
+88			0.	0.	-1.627	0.	0.	-1.627	+88
CBAR	90	103	85	88	0.0	0.0	-1.	1	
+90			0.	0.	-1.627	0.	0.	-1.627	+90
CBAR	92	103	88	91	0.0	0.0	-1.	1	
+92			0.	0.	-1.627	0.	0.	-1.627	+92
CBAR	93	103	91	90	0.0	0.0	-1.	1	
+93			0.	0.	-1.627	0.	0.	-1.627	+93
CBAR	94	101	90	105	1.	0.0	1.	1	
+94			.6212	0.	.6212	.6212	0.	.6212	+94
CBAR	95	101	106	107	0.0	-1.	-1.	1	
+95			0.	-.6212	-.6212	0.	-.6212	-.6212	+95
CBAR	96	101	107	108	0.0	-1.	-1.	1	
+96			0.	-.6212	-.6212	0.	-.6212	-.6212	+96
CBAR	97	101	108	109	0.0	-1.	-1.	1	
+97			0.	-.6212	-.6212	0.	-.6212	-.6212	+97
CBAR	98	101	109	110	0.0	-1.	-1.	1	
+98			0.	-.6212	-.6212	0.	-.6212	-.6212	+98
CBAR	99	101	110	111	0.0	-1.	-1.	1	
+99			0.	-.6212	-.6212	0.	-.6212	-.6212	+99
CBAR	100	101	111	112	0.0	-1.	-1.	1	
+100			0.	-.6212	-.6212	0.	-.6212	-.6212	+100
CBAR	101	101	112	125	-1.	0.0	-1.	1	
+101			-.6212	0.	-.6212	-.6212	0.	-.6212	+101
CBAR	102	101	125	134	-1.	0.0	-1.	1	
+102			-.6212	0.	-.6212	-.6212	0.	-.6212	+102
CBAR	103	101	134	143	-1.	0.0	-1.	1	
+103			-.6212	0.	-.6212	-.6212	0.	-.6212	+103
CBAR	104	101	143	154	-1.	0.0	-1.	1	
+104			-.6212	0.	-.6212	-.6212	0.	-.6212	+104
CBAR	105	101	154	153	0.0	1.	-1.	1	
+105			0.	.6212	-.6212	0.	.6212	-.6212	+105
CBAR	106	101	153	152	0.0	1.	-1.	1	
+106			0.	.6212	-.6212	0.	.6212	-.6212	+106
CBAR	107	101	152	151	0.0	1.	-1.	1	
+107			0.	.6212	-.6212	0.	.6212	-.6212	+107
CBAR	108	101	151	150	0.0	1.	-1.	1	
+108			0.	.6212	-.6212	0.	.6212	-.6212	+108
CBAR	109	101	150	149	0.0	1.	-1.	1	
+109			0.	.6212	-.6212	0.	.6212	-.6212	+109
CBAR	110	101	149	148	0.0	1.	-1.	1	
+110			0.	.6212	-.6212	0.	.6212	-.6212	+110
CBAR	111	101	148	135	1.	0.0	-1.	1	
+111			.6212	0.	-.6212	.6212	0.	-.6212	+111
CBAR	112	101	135	126	1.	0.0	-1.	1	
+112			.6212	0.	-.6212	.6212	0.	-.6212	+112
CBAR	113	101	126	117	1.	0.0	-1.	1	
+113			.6212	0.	-.6212	.6212	0.	-.6212	+113

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CBAR	114	101	117	106	1.	0.0	-1.	1	+114
+114			.6212	0.	-.6212	.6212	0.	1	
CBAR	115	102	117	118	0.0	0.0	-1.	1	+115
+115			0.	0.	-.5906	0.	0.	1	
CBAR	116	102	118	119	0.0	0.0	-1.	1	+116
+116			0.	0.	-.5906	0.	0.	1	
CBAR	117	102	119	120	0.0	0.0	-1.	1	+117
+117			0.	0.	-.5906	0.	0.	1	
CBAR	118	102	120	121	0.0	0.0	-1.	1	+118
+118			0.	0.	-.5906	0.	0.	1	
CBAR	119	102	121	122	0.0	0.0	-1.	1	+119
+119			0.	0.	-.5906	0.	0.	1	
CBAR	120	102	122	123	0.0	0.0	-1.	1	+120
+120			0.	0.	-.5906	0.	0.	1	
CBAR	121	102	123	124	0.0	0.0	-1.	1	+121
+121			0.	0.	-.5906	0.	0.	1	
CBAR	122	102	124	125	0.0	0.0	-1.	1	+122
+122			0.	0.	-.5906	0.	0.	1	
CBAR	123	102	135	136	0.0	0.0	-1.	1	+123
+123			0.	0.	-.5906	0.	0.	1	
CBAR	124	102	136	137	0.0	0.0	-1.	1	+124
+124			0.	0.	-.5906	0.	0.	1	
CBAR	125	102	137	138	0.0	0.0	-1.	1	+125
+125			0.	0.	-.5906	0.	0.	1	
CBAR	126	102	138	139	0.0	0.0	-1.	1	+126
+126			0.	0.	-.5906	0.	0.	1	
CBAR	127	102	139	140	0.0	0.0	-1.	1	+127
+127			0.	0.	-.5906	0.	0.	1	
CBAR	128	102	140	141	0.0	0.0	-1.	1	+128
+128			0.	0.	-.5906	0.	0.	1	
CBAR	129	102	141	142	0.0	0.0	-1.	1	+129
+129			0.	0.	-.5906	0.	0.	1	
CBAR	130	102	142	143	0.0	0.0	-1.	1	+130
+130			0.	0.	-.5906	0.	0.	1	
CBAR	131	102	108	114	0.0	0.0	-1.	1	+131
+131			0.	0.	-.5906	0.	0.	1	
CBAR	132	102	114	119	0.0	0.0	-1.	1	+132
+132			0.	0.	-.5906	0.	0.	1	
CBAR	133	102	119	128	0.0	0.0	-1.	1	+133
+133			0.	0.	-.5906	0.	0.	1	
CBAR	134	102	128	137	0.0	0.0	-1.	1	+134
+134			0.	0.	-.5906	0.	0.	1	
CBAR	135	102	137	145	0.0	0.0	-1.	1	+135
+135			0.	0.	-.5906	0.	0.	1	
CBAR	136	102	145	150	0.0	0.0	-1.	1	+136
+136			0.	0.	-.5906	0.	0.	1	
CBAR	137	102	110	121	0.0	0.0	-1.	1	+137
+137			0.	0.	-.5906	0.	0.	1	
CBAR	138	102	121	130	0.0	0.0	-1.	1	+138
+138			0.	0.	-.5906	0.	0.	1	
CBAR	139	102	130	139	0.0	0.0	-1.	1	+139
+139			0.	0.	-.5906	0.	0.	1	

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OF POOR QUALITY

CBAR	140	102	139	152	0.0	0.0	-1.	1	+140
+140			0.	0.	-.5906	0.	0.	-.5906	
CBAR	141	102	111	116	0.0	0.0	-1.	1	+141
+141			0.	0.	-.5906	0.	0.	-.5906	
CBAR	142	102	116	123	0.0	0.0	-1.	1	+142
+142			0.	0.	-.5906	0.	0.	-.5906	
CBAR	143	102	123	132	0.0	0.0	-1.	1	+143
+143			0.	0.	-.5906	0.	0.	-.5906	
CBAR	144	102	132	141	0.0	0.0	-1.	1	+144
+144			0.	0.	-.5906	0.	0.	-.5906	
CBAR	145	102	141	147	0.0	0.0	-1.	1	+145
+145			0.	0.	-.5906	0.	0.	-.5906	
CBAR	146	102	147	153	0.0	0.0	-1.	1	+146
+146			0.	0.	-.5906	0.	0.	-.5906	
CBAR	147	101	12	163	1.	-1.	0.0	1	+147
+147			.6212	-.6212	0.	.6212	-.6212	0.	
CBAR	148	101	163	172	1.	-1.	0.0	1	+148
+148			.6212	-.6212	0.	.6212	-.6212	0.	
CBAR	149	101	172	181	1.	-1.	0.0	1	+149
+149			.6212	-.6212	0.	.6212	-.6212	0.	
CBAR	150	101	181	190	1.	-1.	0.0	1	+150
+150			.6212	-.6212	0.	.6212	-.6212	0.	
CBAR	151	101	190	106	1.	-1.	0.0	1	+151
+151			.6212	-.6212	0.	.6212	-.6212	0.	
CBAR	152	101	112	182	-1.	-1.	0.0	1	+152
+152			-.6212	-.6212	0.	-.6212	-.6212	0.	
CBAR	153	101	182	173	-1.	-1.	0.0	1	+153
+153			-.6212	-.6212	0.	-.6212	-.6212	0.	
CBAR	154	101	173	164	-1.	-1.	0.0	1	+154
+154			-.6212	-.6212	0.	-.6212	-.6212	0.	
CBAR	155	101	164	155	-1.	-1.	0.0	1	+155
+155			-.6212	-.6212	0.	-.6212	-.6212	0.	
CBAR	156	101	155	1	-1.	-1.	0.0	1	+156
+156			-.6212	-.6212	0.	-.6212	-.6212	0.	
CBAR	157	102	7	159	0.0	-1.	0.0	1	+157
+157			0.	-.5906	0.	0.	-.5906	0.	
CBAR	158	102	159	168	0.0	-1.	0.0	1	+158
+158			0.	-.5906	0.	0.	-.5906	0.	
CBAR	159	102	168	177	0.0	-1.	0.0	1	+159
+159			0.	-.5906	0.	0.	-.5906	0.	
CBAR	160	102	177	186	0.0	-1.	0.0	1	+160
+160			0.	-.5906	0.	0.	-.5906	0.	
CBAR	161	102	186	110	0.0	-1.	0.0	1	+161
+161			0.	-.5906	0.	0.	-.5906	0.	
CBAR	162	102	9	161	0.0	-1.	0.0	1	+162
+162			0.	-.5906	0.	0.	-.5906	0.	
CBAR	163	102	161	170	0.0	-1.	0.0	1	+163
+163			0.	-.5906	0.	0.	-.5906	0.	
CBAR	164	102	170	179	0.0	-1.	0.0	1	+164
+164			0.	-.5906	0.	0.	-.5906	0.	
CBAR	165	102	179	188	0.0	-1.	0.0	1	+165
+165			0.	-.5906	0.	0.	-.5906	0.	

# ORIGINAL LISTING OF POOR QUALITY

CBAR	166	102	188	192	0.0	-1.	0.0	1	+166
+166			0.	192	-.5906	0.	0.	0.	
CBAR	167	102	192	108	0.0	-1.	-.5906	0.	
+167			0.	178	-.5906	0.	0.0	1	+167
CBAR	168	102	177	178	0.0	0.	-.5906	0.	
+168			0.	179	-.5906	-1.	0.0	1	+168
CBAR	169	102	178	179	0.0	0.	-.5906	0.	
+169			0.	180	-.5906	-1.	0.0	1	+169
CBAR	170	102	179	180	0.0	0.	-.5906	0.	
+170			0.	181	-.5906	-1.	0.0	1	+170
CBAR	171	102	180	181	0.0	0.	-.5906	0.	
+171			0.	181	-.5906	-1.	0.0	1	+171
CBAR	172	101	94	202	0.	0.	-.5906	0.	
+172			-.6212	202	-1.	1.	0.0	1	+172
CBAR	173	101	202	211	-1.	1.	-.6212	0.	
+173			-.6212	211	0.	1.	0.0	1	+173
CBAR	174	101	211	220	-1.	1.	-.6212	0.	
+174			-.6212	220	0.	1.	0.0	1	+174
CBAR	175	101	220	229	-1.	1.	-.6212	0.	
+175			-.6212	229	0.	1.	0.0	1	+175
CBAR	176	101	229	154	-1.	1.	-.6212	0.	
+176			-.6212	154	0.	1.	0.0	1	+176
CBAR	177	101	148	221	1.	1.	-.6212	0.	
+177			-.6212	221	0.	1.	0.0	1	+177
CBAR	178	101	221	212	1.	1.	-.6212	0.	
+178			-.6212	212	0.	1.	0.0	1	+178
CBAR	179	101	212	203	1.	1.	-.6212	0.	
+179			-.6212	203	0.	1.	0.0	1	+179
CBAR	180	101	203	194	1.	1.	-.6212	0.	
+180			-.6212	194	0.	1.	0.0	1	+180
CBAR	181	101	194	105	1.	1.	-.6212	0.	
+181			-.6212	105	0.	1.	0.0	1	+181
CBAR	182	102	102	196	0.0	1.	-.6212	0.	
+182			0.	196	0.0	1.	0.0	1	+182
CBAR	183	102	196	205	0.0	1.	-.5906	0.	
+183			0.	205	0.0	1.	0.0	1	+183
CBAR	184	102	205	214	0.0	1.	-.5906	0.	
+184			0.	214	0.0	1.	0.0	1	+184
CBAR	185	102	214	223	0.0	1.	-.5906	0.	
+185			0.	223	0.0	1.	0.0	1	+185
CBAR	186	102	223	231	0.0	1.	-.5906	0.	
+186			0.	231	0.0	1.	0.0	1	+186
CBAR	187	102	231	150	0.0	1.	-.5906	0.	
+187			0.	150	0.0	1.	0.0	1	+187
CBAR	188	102	100	198	0.0	1.	-.5906	0.	
+188			0.	198	0.0	1.	0.0	1	+188
CBAR	189	102	198	207	0.0	1.	-.5906	0.	
+189			0.	207	0.0	1.	0.0	1	+189
CBAR	190	102	207	216	0.0	1.	-.5906	0.	
+190			0.	216	0.0	1.	0.0	1	+190
CBAR	191	102	216	225	0.0	1.	-.5906	0.	
+191			0.	225	0.0	1.	0.0	1	+191
				.5906	0.	0.	.5906	0.	

CBAR	192	102	225	152	0.0	1.	0.0	1	+192
+192			0.	.5906	0.	0.	.5906	0.	
CBAR	193	102	212	213	0.0	1.	0.0	1	+193
+193			0.	.5906	0.	0.	.5906	0.	
CBAR	194	102	213	214	0.0	1.	0.0	1	+194
+194			0.	.5906	0.	0.	.5906	0.	
CBAR	195	102	214	215	0.0	1.	0.0	1	+195
+195			0.	.5906	0.	0.	.5906	0.	
CBAR	196	102	215	216	0.0	1.	0.0	1	+196
+196			0.	.5906	0.	0.	.5906	0.	
CBAR	205	102	40	259	1.	0.0	0.0	1	+205
CBAR	206	102	259	261	1.	0.0	0.0	1	+206
CBAR	207	102	261	265	1.	0.0	0.0	1	+207
CBAR	208	102	265	267	1.	0.0	0.0	1	+208
CBAR	209	102	267	269	1.	0.0	0.0	1	+209
CBAR	210	102	269	273	1.	0.0	0.0	1	+210
CBAR	211	102	273	123	1.	0.0	0.0	1	+211
CBAR	212	102	62	260	1.	0.0	0.0	1	+212
CBAR	213	102	260	264	1.	0.0	0.0	1	+213
CBAR	214	102	264	266	1.	0.0	0.0	1	+214
CBAR	215	102	266	268	1.	0.0	0.0	1	+215
CBAR	216	102	268	272	1.	0.0	0.0	1	+216
CBAR	217	102	272	274	1.	0.0	0.0	1	+217
CBAR	218	102	274	141	1.	0.0	0.0	1	+218
CBAR	219	102	261	262	1.	0.0	0.0	1	+219
CBAR	220	102	262	263	1.	0.0	0.0	1	+220
CBAR	221	102	263	264	1.	0.0	0.0	1	+221
CBAR	222	102	269	270	1.	0.0	0.0	1	+222
CBAR	223	102	270	271	1.	0.0	0.0	1	+223
CBAR	224	102	271	272	1.	0.0	0.0	1	+224
CBAR	267	102	177	376	1.	0.0	0.0	1	+267
+267			0.	0.	0.	0.	0.	0.	
CBAR	268	102	376	377	1.	0.0	0.0	1	+268
+268			0.	0.	0.	0.	0.	0.	
CBAR	269	102	377	216	1.	0.0	0.0	1	+269
+269			0.	0.	0.	0.	0.	0.	
CQUAD1	401	401	25	37	38	26			
CQUAD1	402	401	37	48	49	38			
CQUAD1	403	401	48	59	60	49			
CQUAD1	404	401	59	70	71	60			
CQUAD1	407	401	26	38	39	27			
CQUAD1	408	401	38	49	50	39			
CQUAD1	409	401	49	60	61	50			
CQUAD1	410	401	60	71	72	61			
CQUAD1	427	401	41	52	53	42			
CQUAD1	428	401	52	63	64	53			
CQUAD1	433	401	42	53	54	43			
CQUAD1	434	401	53	64	65	54			
CQUAD1	447	401	34	45	46	35			
CQUAD1	448	401	45	56	57	46			
CQUAD1	449	401	56	67	68	57			
CQUAD1	450	401	67	79	80	68			

CQUAD1	453	401	35	46	47	36
CQUAD1	454	401	46	57	58	47
CQUAD1	455	401	57	68	69	58
CQUAD1	456	401	68	80	81	69
CQUAD1	457	402	117	126	127	118
CQUAD1	458	402	126	135	136	127
CQUAD1	459	402	113	118	119	114
CQUAD1	460	402	118	127	128	119
CQUAD1	461	402	127	136	137	128
CQUAD1	463	402	114	119	120	115
CQUAD1	464	402	119	128	129	120
CQUAD1	465	402	128	137	138	129
CQUAD1	466	402	137	145	146	138
CQUAD1	467	402	120	129	130	121
CQUAD1	468	402	129	138	139	130
CQUAD1	473	402	159	160	169	168
CQUAD1	474	402	160	161	170	169
CQUAD1	475	402	161	162	171	170
CQUAD1	476	402	162	163	172	171
CQUAD1	481	402	168	169	178	177
CQUAD1	482	402	169	170	179	178
CQUAD1	483	402	170	171	180	179
CQUAD1	484	402	171	172	181	180
CQUAD1	491	402	179	180	189	188
CQUAD1	492	402	180	181	190	189
CQUAD1	494	402	188	189	193	192
CQUAD1	495	402	194	195	204	203
CQUAD1	496	402	195	196	205	204
CQUAD1	497	402	196	197	206	205
CQUAD1	498	402	197	198	207	206
CQUAD1	503	402	203	204	213	212
CQUAD1	504	402	204	205	214	213
CQUAD1	505	402	205	206	215	214
CQUAD1	506	402	206	207	216	215
CQUAD1	511	402	212	213	222	221
CQUAD1	512	402	213	214	223	222
CQUAD1	519	402	222	223	231	230
CQUAD1	523	401	155	233	238	164
CQUAD1	524	401	234	235	240	239
CQUAD1	525	401	235	236	241	240
CQUAD1	526	401	237	202	211	242
CQUAD1	527	401	164	238	243	173
CQUAD1	528	401	238	239	244	243
CQUAD1	529	401	241	242	246	245
CQUAD1	530	401	242	211	220	246
CQUAD1	531	401	173	243	249	182
CQUAD1	532	401	243	244	250	249
CQUAD1	533	401	245	246	253	252
CQUAD1	534	401	246	220	229	253
CQUAD2	405	404	2	13	14	3
CQUAD2	406	404	13	26	27	14
CQUAD2	411	404	71	82	83	72

CQUAD2	412	404	82	95	96	83
CQUAD2	413	404	3	14	16	4
CQUAD2	414	404	14	27	28	16
CQUAD2	415	404	72	83	85	73
CQUAD2	416	404	83	96	97	85
CQUAD2	417	404	4	16	17	5
CQUAD2	418	404	16	28	29	17
CQUAD2	419	404	73	85	86	74
CQUAD2	420	404	85	97	98	86
CQUAD2	421	404	5	17	18	6
CQUAD2	422	404	17	29	30	18
CQUAD2	423	404	74	86	87	75
CQUAD2	424	404	86	98	99	87
CQUAD2	425	404	6	18	19	7
CQUAD2	426	404	18	30	31	19
CQUAD2	429	404	75	87	88	76
CQUAD2	430	404	87	99	100	88
CQUAD2	431	404	7	19	20	8
CQUAD2	432	404	19	31	32	20
CQUAD2	435	404	76	88	89	77
CQUAD2	436	404	88	100	101	89
CQUAD2	437	404	8	20	22	9
CQUAD2	438	404	20	32	33	22
CQUAD2	439	404	77	89	91	78
CQUAD2	440	404	89	101	102	91
CQUAD2	441	404	9	22	23	10
CQUAD2	442	404	22	33	34	23
CQUAD2	443	404	78	91	92	79
CQUAD2	444	404	91	102	103	92
CQUAD2	445	404	10	23	24	11
CQUAD2	446	404	23	34	35	24
CQUAD2	451	404	79	92	93	80
CQUAD2	452	404	92	103	104	93
CQUAD2	462	403	136	144	145	137
CQUAD2	469	403	155	156	165	164
CQUAD2	470	403	156	157	166	165
CQUAD2	471	403	157	158	167	166
CQUAD2	472	403	158	159	168	167
CQUAD2	477	403	164	165	174	173
CQUAD2	478	403	165	166	175	174
CQUAD2	479	403	166	167	176	175
CQUAD2	480	403	167	168	177	176
CQUAD2	485	403	173	174	183	182
CQUAD2	486	403	174	175	184	183
CQUAD2	487	403	175	176	185	184
CQUAD2	488	403	176	177	186	185
CQUAD2	489	403	177	178	187	186
CQUAD2	490	403	178	179	188	187
CQUAD2	493	403	187	188	192	191
CQUAD2	499	403	198	199	208	207
CQUAD2	500	403	199	200	209	208
CQUAD2	501	403	200	201	210	209

CQUAD2	502	403	201	202	211	210
CQUAD2	507	403	207	208	217	216
CQUAD2	508	403	208	209	218	217
CQUAD2	509	403	209	210	219	218
CQUAD2	510	403	210	211	220	219
CQUAD2	513	403	214	215	224	223
CQUAD2	514	403	215	216	225	224
CQUAD2	515	403	216	217	226	225
CQUAD2	516	403	217	218	227	226
CQUAD2	517	403	218	219	228	227
CQUAD2	518	403	219	220	229	228
CQUAD2	520	403	223	224	232	231
CRIGD2	1055	55	54	45		
CTRIA1	607	301	40	28	27	
CTRIA1	608	301	27	39	40	
CTRIA1	609	301	39	50	40	
CTRIA1	610	301	51	40	50	
CTRIA1	611	301	62	51	50	
CTRIA1	612	301	50	61	62	
CTRIA1	613	301	61	72	62	
CTRIA1	614	301	73	62	72	
CTRIA1	615	301	28	40	29	
CTRIA1	616	301	40	41	29	
CTRIA1	617	301	52	41	40	
CTRIA1	618	301	40	51	52	
CTRIA1	619	301	51	62	52	
CTRIA1	620	301	63	52	62	
CTRIA1	621	301	63	62	74	
CTRIA1	622	301	62	73	74	
CTRIA1	623	301	30	29	41	
CTRIA1	624	301	41	42	30	
CTRIA1	625	301	42	31	30	
CTRIA1	626	301	74	75	63	
CTRIA1	627	301	64	63	75	
CTRIA1	628	301	75	76	64	
CTRIA1	629	301	31	42	32	
CTRIA1	630	301	42	43	32	
CTRIA1	631	301	65	64	77	
CTRIA1	632	301	64	76	77	
CTRIA1	633	301	33	32	43	
CTRIA1	634	301	44	33	43	
CTRIA1	639	301	78	66	65	
CTRIA1	640	301	77	78	65	
CTRIA1	641	301	45	34	33	
CTRIA1	642	301	33	44	45	
CTRIA1	643	301	44	55	45	
CTRIA1	644	301	56	45	55	
CTRIA1	645	301	67	56	55	
CTRIA1	646	301	55	66	67	
CTRIA1	647	301	66	78	67	
CTRIA1	648	301	79	67	78	
CTRIA1	655	302	113	107	106	

CTRIA1	656	302	106	117	113
CTRIA1	657	302	118	113	117
CTRIA1	658	302	144	136	135
CTRIA1	659	302	135	148	144
CTRIA1	660	302	149	144	148
CTRIA1	661	302	107	113	108
CTRIA1	662	302	114	108	113
CTRIA1	663	302	150	145	114
CTRIA1	664	302	144	149	150
CTRIA1	669	302	109	115	110
CTRIA1	670	302	121	110	115
CTRIA1	671	302	115	120	121
CTRIA1	672	302	138	146	139
CTRIA1	673	302	152	139	146
CTRIA1	674	302	146	151	152
CTRIA1	675	302	110	121	122
CTRIA1	676	302	110	122	116
CTRIA1	677	302	116	111	110
CTRIA1	678	302	123	116	122
CTRIA1	679	302	131	122	121
CTRIA1	680	302	121	130	131
CTRIA1	681	302	130	139	131
CTRIA1	682	302	140	131	139
CTRIA1	683	302	122	131	123
CTRIA1	684	302	132	123	131
CTRIA1	685	302	141	132	131
CTRIA1	686	302	131	140	141
CTRIA1	687	302	147	141	140
CTRIA1	688	302	139	152	140
CTRIA1	689	302	140	152	147
CTRIA1	690	302	153	147	152
CTRIA1	691	302	111	116	112
CTRIA1	692	302	116	123	124
CTRIA1	693	302	112	116	124
CTRIA1	694	302	125	112	124
CTRIA1	695	302	133	124	123
CTRIA1	696	302	123	132	133
CTRIA1	697	302	132	141	133
CTRIA1	698	302	142	133	141
CTRIA1	699	302	124	133	125
CTRIA1	700	302	134	125	133
CTRIA1	701	302	143	134	133
CTRIA1	702	302	133	142	143
CTRIA1	703	302	154	143	142
CTRIA1	704	302	141	147	142
CTRIA1	705	302	147	154	142
CTRIA1	706	302	147	153	154
CTRIA1	717	302	7	8	159
CTRIA1	718	302	160	159	8
CTRIA1	719	302	161	160	8
CTRIA1	720	302	8	9	161
CTRIA1	721	302	9	10	161

CTRIAL	722	302	162	161	10
CTRIAL	723	302	10	11	162
CTRIAL	724	302	163	162	11
CTRIAL	725	302	11	12	163
CTRIAL	737	302	192	193	108
CTRIAL	738	302	107	108	193
CTRIAL	739	302	106	107	193
CTRIAL	740	302	190	106	193
CTRIAL	741	302	189	190	193
CTRIAL	742	302	105	104	194
CTRIAL	743	302	195	194	104
CTRIAL	744	302	104	103	195
CTRIAL	745	302	196	195	103
CTRIAL	746	302	103	102	196
CTRIAL	747	302	102	101	196
CTRIAL	748	302	197	196	101
CTRIAL	749	302	198	197	101
CTRIAL	750	302	101	100	198
CTRIAL	761	302	221	222	230
CTRIAL	762	302	148	221	230
CTRIAL	763	302	149	148	230
CTRIAL	764	302	150	149	230
CTRIAL	765	302	230	231	150
CTRIAL	777	301	239	238	234
CTRIAL	778	301	238	237	234
CTRIAL	779	301	233	25	234
CTRIAL	780	301	25	37	234
CTRIAL	781	301	37	48	234
CTRIAL	782	301	235	234	48
CTRIAL	783	301	236	235	48
CTRIAL	784	301	48	59	236
CTRIAL	785	301	59	70	237
CTRIAL	786	301	236	59	237
CTRIAL	787	301	237	242	236
CTRIAL	788	301	242	241	236
CTRIAL	789	301	239	240	244
CTRIAL	790	301	245	244	240
CTRIAL	791	301	240	241	245
CTRIAL	792	301	251	250	244
CTRIAL	793	301	244	245	251
CTRIAL	794	301	252	251	245
CTRIAL	795	301	112	182	254
CTRIAL	796	301	182	249	254
CTRIAL	797	301	254	249	255
CTRIAL	798	301	249	250	255
CTRIAL	799	301	250	251	255
CTRIAL	800	301	256	255	251
CTRIAL	801	301	257	256	251
CTRIAL	802	301	251	252	257
CTRIAL	803	301	252	253	257
CTRIAL	804	301	253	258	257
CTRIAL	805	301	253	229	258

CTRIA1	806	301	229	154	258
CTRIA1	807	301	125	112	254
CTRIA1	808	301	255	125	254
CTRIA1	809	301	134	125	255
CTRIA1	810	301	255	256	134
CTRIA1	811	301	256	257	134
CTRIA1	812	301	143	134	257
CTRIA1	813	301	143	257	258
CTRIA1	814	301	154	143	258
CTRIA1	951	301	1	15	155
CTRIA1	952	301	233	155	15
CTRIA1	953	301	15	25	233
CTRIA1	954	301	70	84	237
CTRIA1	955	301	202	237	84
CTRIA1	956	301	84	94	202
CTRIA2	601	304	13	2	1
CTRIA2	602	304	1	15	13
CTRIA2	603	304	26	13	25
CTRIA2	604	304	82	71	70
CTRIA2	605	304	70	84	82
CTRIA2	606	304	95	82	94
CTRIA2	635	304	55	44	43
CTRIA2	636	304	43	54	55
CTRIA2	637	304	54	65	55
CTRIA2	638	304	66	55	65
CTRIA2	649	304	11	24	12
CTRIA2	650	304	36	21	24
CTRIA2	651	304	24	35	36
CTRIA2	652	304	80	93	81
CTRIA2	653	304	90	81	93
CTRIA2	654	304	93	104	105
CTRIA2	665	304	115	109	108
CTRIA2	666	304	108	114	115
CTRIA2	667	304	145	150	146
CTRIA2	668	304	151	146	150
CTRIA2	707	303	156	155	1
CTRIA2	708	303	1	2	156
CTRIA2	709	303	2	3	156
CTRIA2	710	303	157	156	3
CTRIA2	711	303	3	4	157
CTRIA2	712	303	4	5	157
CTRIA2	713	303	158	157	5
CTRIA2	714	303	5	6	158
CTRIA2	715	303	159	158	6
CTRIA2	716	303	6	7	159
CTRIA2	726	303	182	183	112
CTRIA2	727	303	111	112	183
CTRIA2	728	303	183	184	111
CTRIA2	729	303	184	185	111
CTRIA2	730	303	110	111	185
CTRIA2	731	303	185	186	110
CTRIA2	732	303	186	187	191

CTRIA2	733	303	110	186	191				
CTRIA2	734	303	109	110	191				
CTRIA2	735	303	108	109	1191				
CTRIA2	736	303	1191	192	108				
CTRIA2	751	303	100	99	198				
CTRIA2	752	303	199	198	99				
CTRIA2	753	303	99	98	199				
CTRIA2	754	303	200	199	98				
CTRIA2	755	303	98	97	200				
CTRIA2	756	303	97	96	200				
CTRIA2	757	303	201	200	96				
CTRIA2	758	303	96	95	201				
CTRIA2	759	303	202	201	95				
CTRIA2	760	303	95	94	202				
CTRIA2	766	303	231	1232	150				
CTRIA2	767	303	151	150	1232				
CTRIA2	768	303	152	151	232				
CTRIA2	769	303	225	152	232				
CTRIA2	770	303	224	225	232				
CTRIA2	771	303	225	226	152				
CTRIA2	772	303	153	152	226				
CTRIA2	773	303	226	227	153				
CTRIA2	774	303	227	228	153				
CTRIA2	775	303	154	153	228				
CTRIA2	776	303	228	229	154				
CTRIA2	957	304	15	25	13				
CTRIA2	958	304	84	94	82				
CTRIA2	959	304	21	12	24				
CTRIA2	960	304	105	90	93				
EIGR	100	GIV	2.0	600.	50	56	6	.1	+EIGR
+EIGR	MAX								
GRID	1		51.00	21.00	-21.00				
GRID	2		44.30	21.00	-21.00				
GRID	3		41.00	21.00	-21.00				
GRID	4		37.250	21.00	-21.00				
GRID	5		33.16	21.00	-21.00				
GRID	6		29.08	21.00	-21.00				
GRID	7		25.00	21.00	-21.00				
GRID	8		19.625	21.00	-21.00				
GRID	9		13.625	21.00	-21.00				
GRID	10		10.20	21.00	-21.00				
GRID	11		6.70	21.00	-21.00				
GRID	12		.00	21.00	-21.00				
GRID	13		44.30	17.125	-21.00		6		
GRID	14		41.00	17.125	-21.00		6		
GRID	15		51.00	17.125	-21.				
GRID	16		37.25	17.125	-21.00				
GRID	17		33.16	17.125	-21.00		6		
GRID	18		29.08	17.125	-21.00		6		
GRID	19		25.00	17.125	-21.00				
GRID	20		19.625	17.125	-21.00		6		
GRID	21		0.0	17.125	-21.				

GRID	22	13.625	17.125	-21.00	
GRID	23	10.20	17.125	-21.00	6
GRID	24	6.70	17.125	-21.00	6
GRID	25	51.00	13.10	-21.00	
GRID	26	44.30	13.10	-21.00	6
GRID	27	41.00	13.10	-21.00	6
GRID	28	37.25	13.38	-21.00	
GRID	29	33.16	13.10	-21.00	6
GRID	30	29.08	13.10	-21.00	6
GRID	31	25.00	13.10	-21.00	
GRID	32	19.625	13.10	-21.00	6
GRID	33	13.625	13.10	-21.00	
GRID	34	10.20	13.10	-21.00	6
GRID	35	6.70	13.10	-21.00	6
GRID	36	.00	13.10	-21.00	
GRID	37	51.00	7.00	-21.00	
GRID	38	44.30	7.00	-21.00	
GRID	39	41.00	7.00	-21.00	
GRID	40	37.25	7.00	-21.00	
GRID	41	31.20	7.00	-21.00	
GRID	42	25.00	7.00	-21.00	
GRID	43	20.425	7.00	-21.00	
GRID	44	13.625	7.00	-21.00	
GRID	45	10.20	7.00	-21.00	
GRID	46	6.70	7.00	-21.00	
GRID	47	.00	7.00	-21.00	
GRID	48	51.00	.00	-21.00	
GRID	49	44.30	.00	-21.00	6
GRID	50	41.00	.00	-21.00	6
GRID	51	37.25	.00	-21.00	
GRID	52	31.20	.00	-21.00	6
GRID	53	25.00	.00	-21.00	
GRID	54	20.425	.00	-21.00	6
GRID	55	13.625	.00	-21.00	
GRID	56	10.20	.00	-21.00	6
GRID	57	6.70	.00	-21.00	6
GRID	58	.00	.00	-21.00	
GRID	59	51.00	-7.00	-21.00	
GRID	60	44.30	-7.00	-21.00	
GRID	61	41.00	-7.00	-21.00	
GRID	62	37.25	-7.00	-21.00	
GRID	63	31.20	-7.00	-21.00	
GRID	64	25.00	-7.00	-21.00	
GRID	65	20.425	-7.00	-21.00	
GRID	66	13.625	-7.00	-21.00	
GRID	67	10.20	-7.00	-21.00	
GRID	68	6.70	-7.00	-21.00	
GRID	69	.00	-7.00	-21.00	
GRID	70	51.00	-13.10	-21.00	
GRID	71	44.30	-13.10	-21.00	6
GRID	72	41.00	-13.10	-21.00	6
GRID	73	37.25	-13.38	-21.00	

GRID	74	33.16	-13.10	-21.00	6
GRID	75	29.08	-13.10	-21.00	6
GRID	76	25.00	-13.10	-21.00	
GRID	77	19.625	-13.10	-21.00	6
GRID	78	13.625	-13.10	-21.00	
GRID	79	10.20	-13.10	-21.00	6
GRID	80	6.70	-13.10	-21.00	6
GRID	81	.00	-13.10	-21.00	
GRID	82	44.30	-17.125	-21.00	6
GRID	83	41.00	-17.125	-21.00	6
GRID	84	51.	-17.125	-21.	
GRID	85	37.25	-17.125	-21.00	
GRID	86	33.16	-17.125	-21.00	6
GRID	87	29.08	-17.125	-21.00	6
GRID	88	25.00	-17.125	-21.00	
GRID	89	19.625	-17.125	-21.00	6
GRID	90	0.0	-17.125	-21.	
GRID	91	13.625	-17.125	-21.00	
GRID	92	10.20	-17.125	-21.00	6
GRID	93	6.70	-17.125	-21.00	6
GRID	94	51.00	-21.00	-21.00	
GRID	95	44.30	-21.00	-21.00	
GRID	96	41.00	-21.00	-21.00	
GRID	97	37.25	-21.00	-21.00	
GRID	98	33.16	-21.00	-21.00	
GRID	99	29.08	-21.00	-21.00	
GRID	100	25.00	-21.00	-21.00	
GRID	101	19.625	-21.00	-21.00	
GRID	102	13.625	-21.00	-21.00	
GRID	103	10.20	-21.00	-21.00	
GRID	104	6.70	-21.00	-21.00	
GRID	105	.00	-21.00	-21.00	
GRID	106	.00	21.00	21.00	
GRID	107	6.812	21.00	21.00	
GRID	108	13.625	21.00	21.00	
GRID	109	19.312	21.00	21.00	
GRID	110	25.00	21.00	21.00	
GRID	111	37.25	21.00	21.00	
GRID	112	51.00	21.00	21.00	
GRID	113	6.812	15.00	21.00	6
GRID	114	13.625	15.00	21.00	
GRID	115	19.312	15.00	21.00	6
GRID	116	37.25	13.38	21.00	
GRID	117	.00	7.00	21.00	
GRID	118	6.812	7.00	21.00	
GRID	119	13.625	7.00	21.00	
GRID	120	19.312	7.00	21.00	
GRID	121	25.00	7.00	21.00	
GRID	122	31.125	7.00	21.00	
GRID	123	37.25	7.00	21.00	
GRID	124	44.125	7.00	21.00	
GRID	125	51.00	7.00	21.00	

GRID	126	.00	.00	21.00	
GRID	127	6.812	.00	21.00	6
GRID	128	13.625	.00	21.00	
GRID	129	19.312	.00	21.00	6
GRID	130	25.00	.00	21.00	
GRID	131	31.125	.00	21.00	6
GRID	132	37.25	.00	21.00	
GRID	133	44.125	.00	21.00	6
GRID	134	51.00	.00	21.00	
GRID	135	.00	-7.00	21.00	
GRID	136	6.812	-7.00	21.00	
GRID	137	13.625	-7.00	21.00	
GRID	138	19.312	-7.00	21.00	
GRID	139	25.00	-7.00	21.00	
GRID	140	31.125	-7.00	21.00	
GRID	141	37.25	-7.00	21.00	
GRID	142	44.125	-7.00	21.00	
GRID	143	51.00	-7.00	21.00	
GRID	144	6.812	-15.00	21.00	6
GRID	145	13.625	-15.00	21.00	
GRID	146	19.312	-15.00	21.00	6
GRID	147	37.25	-13.38	21.00	
GRID	148	.00	-21.00	21.00	
GRID	149	6.812	-21.00	21.00	
GRID	150	13.625	-21.00	21.00	
GRID	151	19.312	-21.00	21.00	
GRID	152	25.00	-21.00	21.00	
GRID	153	37.25	-21.00	21.00	
GRID	154	51.00	-21.00	21.00	
GRID	155	51.00	21.00	-14.00	
GRID	156	44.30	21.00	-14.00	5
GRID	157	37.25	21.00	-14.00	5
GRID	158	31.125	21.00	-14.00	5
GRID	159	25.00	21.00	-14.00	
GRID	160	19.625	21.00	-14.00	5
GRID	161	13.625	21.00	-14.00	
GRID	162	6.70	21.00	-14.00	5
GRID	163	.00	21.00	-14.00	
GRID	164	51.00	21.00	-7.00	
GRID	165	44.30	21.00	-7.00	5
GRID	166	37.25	21.00	-7.00	5
GRID	167	31.125	21.00	-7.00	5
GRID	168	25.00	21.00	-7.00	
GRID	169	19.625	21.00	-7.00	5
GRID	170	13.625	21.00	-7.00	
GRID	171	6.70	21.00	-7.00	5
GRID	172	.00	21.00	-7.00	
GRID	173	51.00	21.00	.00	
GRID	174	44.30	21.00	.00	5
GRID	175	37.25	21.00	.00	5
GRID	176	31.125	21.00	.00	5
GRID	177	25.00	21.00	.00	

GRID	178	19.625	21.00	.00	
GRID	179	13.625	21.00	.00	
GRID	180	6.70	21.00	.00	
GRID	181	.00	21.00	.00	
GRID	182	51.00	21.00	10.50	
GRID	183	44.30	21.00	10.50	5
GRID	184	37.25	21.00	10.50	5
GRID	185	31.125	21.00	10.50	5
GRID	186	25.00	21.00	10.50	
GRID	187	19.625	21.00	10.50	5
GRID	188	13.625	21.00	10.50	
GRID	189	6.70	21.00	10.50	5
GRID	190	.00	21.00	10.50	
GRID	191	19.625	21.00	15.00	5
GRID	192	13.625	21.00	15.00	
GRID	193	6.70	21.00	15.00	5
GRID	194	.00	-21.00	-14.00	
GRID	195	6.70	-21.00	-14.00	5
GRID	196	13.625	-21.00	-14.00	
GRID	197	19.625	-21.00	-14.00	5
GRID	198	25.00	-21.00	-14.00	
GRID	199	31.125	-21.00	-14.00	5
GRID	200	37.25	-21.00	-14.00	5
GRID	201	44.30	-21.00	-14.00	5
GRID	202	51.00	-21.00	-14.00	
GRID	203	.00	-21.00	-7.00	
GRID	204	6.70	-21.00	-7.00	5
GRID	205	13.625	-21.00	-7.00	
GRID	206	19.625	-21.00	-7.00	5
GRID	207	25.00	-21.00	-7.00	
GRID	208	31.125	-21.00	-7.00	5
GRID	209	37.25	-21.00	-7.00	5
GRID	210	44.30	-21.00	-7.00	5
GRID	211	51.00	-21.00	-7.00	
GRID	212	.00	-21.00	.00	
GRID	213	6.70	-21.00	.00	
GRID	214	13.625	-21.00	.00	
GRID	215	19.625	-21.00	.00	
GRID	216	25.00	-21.00	.00	
GRID	217	31.125	-21.00	.00	5
GRID	218	37.25	-21.00	.00	5
GRID	219	44.30	-21.00	.00	5
GRID	220	51.00	-21.00	.00	
GRID	221	.00	-21.00	10.50	
GRID	222	6.70	-21.00	10.50	5
GRID	223	13.625	-21.00	10.50	
GRID	224	19.625	-21.00	10.50	5
GRID	225	25.00	-21.00	10.50	
GRID	226	31.125	-21.00	10.50	5
GRID	227	37.25	-21.00	10.50	5
GRID	228	44.30	-21.00	10.50	5
GRID	229	51.00	-21.00	10.50	

GRID	230	6.70	-21.00	15.00	5	
GRID	231	13.625	-21.00	15.00		
GRID	232	19.625	-21.00	15.00	5	
GRID	233	51.00	13.10	-14.00	4	
GRID	234	51.00	7.50	-11.00		
GRID	235	51.00	1.125	-11.00		
GRID	236	51.00	-5.25	-11.00		
GRID	237	51.00	-13.10	-14.00	4	
GRID	238	51.00	13.10	-7.00	4	
GRID	239	51.00	7.50	-7.00	4	
GRID	240	51.00	1.125	-7.00	4	
GRID	241	51.00	-5.25	-7.00	4	
GRID	242	51.00	-13.10	-7.00	4	
GRID	243	51.00	13.10	.00	4	
GRID	244	51.00	7.50	.00	4	
GRID	245	51.00	-5.25	.00	4	
GRID	246	51.00	-13.10	.00	4	
GRID	249	51.00	13.10	10.50	4	
GRID	250	51.00	7.50	10.50	4	
GRID	251	51.00	1.125	10.50	4	
GRID	252	51.00	-5.25	10.50	4	
GRID	253	51.00	-13.10	10.50	4	
GRID	254	51.00	13.10	16.00	4	
GRID	255	51.00	7.50	13.50		
GRID	256	51.00	1.125	13.50		
GRID	257	51.00	-5.25	13.50		
GRID	258	51.00	-13.10	16.00	4	
GRID	259	37.25	7.00	-11.97		
GRID	260	37.25	-7.00	-11.97		
GRID	261	37.25	7.00	-7.75		
GRID	262	37.25	3.00	-7.75		
GRID	263	37.25	-3.00	-7.75		
GRID	264	37.25	-7.00	-7.75		
GRID	265	37.25	7.00	-3.97		
GRID	266	37.25	-7.00	-3.97		
GRID	267	37.25	7.00	3.97		
GRID	268	37.25	-7.00	3.97		
GRID	269	37.25	7.00	7.75		
GRID	270	37.25	3.00	7.75		
GRID	271	37.25	-3.00	7.75		
GRID	272	37.25	-7.00	7.75		
GRID	273	37.25	7.00	11.97		
GRID	274	37.25	-7.00	11.97		
GRID	376	25.00	7.00	.00		
GRID	377	25.00	-7.00	.00		
GRID	1191	19.625	21.	15.	5	
GRID	1232	19.625	-21.	15.	5	
MAT1	100	10.0+6	3.8+6	.098		+606
+6061T6	35000.	34000.	24000.			
MAT1	107	10.3+6	.33			+DUM
+DUMMY	56000.	56000.	39000.			
MAT1	200	60.+3	.2			+HC

+HC	20000.	20000.	20000.						
MAT1	300	29.+6	11.+6		.283				+413
+4130	132000.	145000.	95000.						
MAT1	400	29.+6	11.+6						+BOT
+BOTTLE	132000.	145000.	95000.						
PARAM	WTMASS	.002588							
PBAR	101	100	.8464	.29362	.35875	.26999			+P10
+P101A	.6949	.9723	.6949	-.9723	-1.0607	0.			+P10
+P101B	.5	.5							
PBAR	102	100	1.00265	.33208	.54104	.27325			+P10
+P102A	1.2094	0.	-.1656	-1.375	-.9156	0.	-.1656	1.375	+P10
+P102B	.5	.5							
PBAR	103	300	3.25	5.0485	1.1615	.2708			+P10
+P103A	2.673	0.	-1.327	-1.5	-1.327	1.5			+P10
+P103B	.5	.5							
PBAR	104	400	5.348	86.142	86.142	172.28	2.0691		+P10
+P104A	5.75	0.	0.	-5.75	-5.75	0.	0.	5.75	+P10
+P104B	.5	.5							
PBAR	105	100	2.25	1.6875	.1055	.4219			+P10
+P105A	1.5	.375	1.5	-.375	-1.5	-.375	-1.5	.375	+P10
+P105B	.5	.5							
PBAR	106	107	3.7492	33.146	.0414	.1656	3.2437		+P10
+P106A	5.15	.182	5.15	-.182	-5.15	-.182	-5.15	.182	+P10
+P106B	.5	.5							
PBAR	107	107	4.288	22.869	.1027	.4106	1.9563		+P10
+P107A	4.00	.268	4.00	-.268	-4.00	-.268	-4.00	.268	+P10
+P107B	.5	.5							
PQUAD1	401	100	.080	100	.006272	200	.520	.002407	+P40
+P401	-.300	.300							
PQUAD1	402	100	.040	100	.002916	200	.520	.002407	+P40
+P402	-.280	.280							
PQUAD2	403	100	.250						
PQUAD2	404	100	.600						
PQUAD2	405	107	.3759						
PQUAD2	406	107	.3151						
PTRIA1	301	100	.080	100	.006272	200	.520	.002407	+P30
+P301	-.300	.300							
PTRIA1	302	100	.040	100	.002916	200	.520	.002407	+P30
+P302	-.280	.280							
PTRIA2	303	100	.250						
PTRIA2	304	100	.600						
PTRIA2	305	107	.3759						
PTRIA2	306	107	.3151						
SEQGP	3	152	4	172	5	173	6	175	
SEQGP	7	180	8	178	9	179	10	176	
SEQGP	11	177	12	174	21	187	36	221	
SEQGP	13	154	14	155	27	189	50	193	
SEQGP	20	214	32	236	89	262	77	270	
SEQGP	22	212	33	237	78	273	91	260	
SEQGP	23	213	34	235	92	261	79	266	
SEQGP	24	210	35	234	56	267	57	263	
SEQGP	29	222	86	225	74	227	18	209	

SEQGP	30	232	87	231	75	252	52	251
SEQGP	31	233	53	268	76	255	88	254
SEQGP	38	158	39	191	40	223	41	250
SEQGP	42	256	43	258	44	259	45	257
SEQGP	46	249	60	167	61	194	62	226
SEQGP	47	244	58	245	69	246	81	247
SEQGP	48	137	37	127	25	126	15	153
SEQGP	51	224	73	200	85	228	19	211
SEQGP	55	272	54	271	1	122	2	123
SEQGP	63	253	64	269	65	275	66	276
SEQGP	67	274	68	264	16	188	28	190
SEQGP	72	197	82	203	83	196	17	208
SEQGP	80	265	93	248	127	26	113	2
SEQGP	90	238	105	220	104	240	103	239
SEQGP	94	206	84	230	70	205	59	169
SEQGP	98	207	97	199	96	198	95	170
SEQGP	102	242	101	241	100	243	99	229
SEQGP	106	19	107	3	108	4	109	7
SEQGP	110	24	111	25	112	20	125	41
SEQGP	118	9	119	11	120	13	121	14
SEQGP	122	15	123	17	124	18	136	27
SEQGP	134	42	143	55	154	84	153	86
SEQGP	137	30	138	32	139	59	140	61
SEQGP	141	35	142	56	114	1	128	12
SEQGP	144	53	115	6	129	31	146	58
SEQGP	145	36	130	33	116	8	132	16
SEQGP	147	60	163	141	172	104	181	76
SEQGP	148	83	135	54	126	28	117	10
SEQGP	152	88	151	64	150	62	149	57
SEQGP	155	120	159	144	168	109	177	80
SEQGP	156	119	165	102	157	138	166	103
SEQGP	158	139	167	108	160	142	169	107
SEQGP	162	140	171	105	174	75	175	79
SEQGP	176	82	183	47	184	52	185	51
SEQGP	186	50	161	143	170	106	179	78
SEQGP	187	49	189	46	191	23	193	21
SEQGP	188	48	192	22	178	81	180	77
SEQGP	190	45	182	44	173	74	164	91
SEQGP	195	215	204	182	197	217	206	185
SEQGP	196	218	205	183	214	148	223	116
SEQGP	199	201	208	184	200	171	209	161
SEQGP	201	163	210	162	217	150	218	147
SEQGP	202	202	211	165	220	133	229	98
SEQGP	219	132	222	112	224	118	226	114
SEQGP	221	110	212	145	203	181	194	216
SEQGP	225	117	213	146	215	151	259	192
SEQGP	227	115	228	111	230	87	232	90
SEQGP	231	89	198	219	207	186	216	149
SEQGP	233	121	238	92	234	101	235	136
SEQGP	237	204	242	164	243	73	244	99
SEQGP	240	134	239	100	236	166	241	135
SEQGP	246	131	245	130	249	71	250	72

SEQGP	253	97	252	96	131	34	133	29
SEQGP	255	67	256	68	257	69	258	70
SEQGP	261	157	265	125	267	93	269	65
SEQGP	263	128	270	37	271	39	376	85
SEQGP	268	94	272	66	274	40	262	124
SEQGP	273	38	260	195	264	160	266	129
SEQGP	377	113	26	156	49	159	71	168
SEQGP	1191	5	1232	63	251	95	254	43
SPC1	1500	4	234	235	236			
SPC1	1500	4	255	256	257			
SUPORT	12	123456						
ENDDATA								

APPENDIX B. Partial NASTRAN Print File Listing with DIAG 21 and 22

----- DSP ANALYSIS -----  
FREE-FREE MODES

AUGUST 24, 1983

\*\*\* USER INFORMATION MESSAGE 2118, SUBROUTINE GP4PRT -  
DIAG 21 SET-DOF VS. DISP SETS FOLLOWS.

INT	DOF	EXT GP.	DOF	SB	SG	L	A	F	N	G	R	O	S
1		114	- 1					1	1	1		1	
2		114	- 2					2	2	2		2	
3		114	- 3					3	3	3		3	
4		114	- 4					4	4	4		4	
5		114	- 5					5	5	5		5	
6		114	- 6					6	6	6		6	
7		113	- 1					7	7	7		7	
8		113	- 2					8	8	8		8	
9		113	- 3					9	9	9		9	
10		113	- 4					10	10	10		10	
11		113	- 5					11	11	11		11	
12		113	- 6		1			12	12				1
13		107	- 1					12	13	13		12	
14		107	- 2					13	14	14		13	
15		107	- 3					14	15	15		14	
16		107	- 4					15	16	16		15	
17		107	- 5					16	17	17		16	
18		107	- 6					17	18	18		17	
19		108	- 1			1	1	18	19	19			
20		108	- 2			2	2	19	20	20			
21		108	- 3			3	3	20	21	21			
22		108	- 4					21	22	22		18	
23		108	- 5					22	23	23		19	
24		108	- 6					23	24	24		20	
25		1191	- 1					24	25	25		21	
26		1191	- 2					25	26	26		22	
27		1191	- 3					26	27	27		23	
28		1191	- 4					27	28	28		24	
29		1191	- 5		2			28	29	29			2
30		1191	- 6					29	30	30		25	
31		115	- 1					30	31	31		26	
32		115	- 2					31	32	32		27	
33		115	- 3					32	33	33		28	
34		115	- 4					33	34	34		29	
35		115	- 5					34	35	35		30	
36		115	- 6		3			35	36	36			3
37		109	- 1					36	37	37		31	
.		.						.	.	.		.	
.		.						.	.	.		.	

----- DSP ANALYSIS ----- AUGUST 24, 1983  
 FREE-FREE MODES

INT DOF	EXT GP. DOF	SB	SG	L	A	F	N	G	R	O	S
1620	77 - 6		101				1620	1620		107	
1621	54 - 1					1514	1621	1621		1325	
1622	54 - 2					1515	1622	1622		1326	
1623	54 - 3					1516	1623	1623		1327	
1624	54 - 4							1624			
1625	54 - 5							1625			
1626	54 - 6		102				1624	1626		108	
1627	55 - 1			184	190	1517	1625	1627			
1628	55 - 2			185	191	1518	1626	1628			
1629	55 - 3			186	192	1519	1627	1629			
1630	55 - 4					1520	1628	1630		1328	
1631	55 - 5					1521	1629	1631		1329	
1632	55 - 6					1522	1630	1632		1330	
1633	78 - 1					1523	1631	1633		1331	
1634	78 - 2					1524	1632	1634		1332	
1635	78 - 3					1525	1633	1635		1333	
1636	78 - 4					1526	1634	1636		1334	
1637	78 - 5					1527	1635	1637		1335	
1638	78 - 6					1528	1636	1638		1336	
1639	67 - 1					1529	1637	1639		1337	
1640	67 - 2					1530	1638	1640		1338	
1641	67 - 3					1531	1639	1641		1339	
1642	67 - 4					1532	1640	1642		1340	
1643	67 - 5					1533	1641	1643		1341	
1644	67 - 6					1534	1642	1644		1342	
1645	65 - 1					1535	1643	1645		1343	
1646	65 - 2					1536	1644	1646		1344	
1647	65 - 3					1537	1645	1647		1345	
1648	65 - 4					1538	1646	1648		1346	
1649	65 - 5					1539	1647	1649		1347	
1650	65 - 6					1540	1648	1650		1348	
1651	66 - 1					1541	1649	1651		1349	
1652	66 - 2					1542	1650	1652		1350	
1653	66 - 3			187	193	1543	1651	1653			
1654	66 - 4					1544	1652	1654		1351	
1655	66 - 5					1545	1653	1655		1352	
1656	66 - 6					1546	1654	1656		1353	
--- COLUMN TOTALS ---		6	102	187	193	1546	1654	1656	6	1353	

----- DSP ANALYSIS ----- AUGUST 24, 1983  
 FREE-FREE MODES

MPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
1=	54-4	54-5						

SPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
1=	113-6	1191-5	115-6	193-5	191-5	127-6	133-6	129-6
11=	189-5	183-5	187-5	185-5	184-5	144-6	146-6	1232-5
21=	257-4	258-4	249-4	250-4	243-4	174-5	175-5	176-5
31=	238-4	251-4	252-4	253-4	244-4	239-4	234-4	165-5
41=	169-5	167-5	228-5	222-5	226-5	227-5	224-5	156-5
51=	246-4	219-5	240-4	241-4	235-4	157-5	158-5	162-5
61=	217-5	13-6	14-6	26-6	49-6	209-5	210-5	201-5
71=	71-6	200-5	204-5	208-5	206-5	27-6	50-6	83-6
81=	82-6	237-4	17-6	18-6	24-6	23-6	20-6	195-5
91=	86-6	74-6	87-6	30-6	35-6	34-6	32-6	93-6
101=	92-6	89-6	57-6	80-6	79-6	56-6	77-6	54-6

----- DSP ANALYSIS -----  
FREE-FREE MODES

AUGUST 24, 1983

OMIT DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
1=	114-1	114-2	114-3	114-4	114-5	114-6	113-1	113-2
11=	113-5	107-1	107-2	107-3	107-4	107-5	107-6	108-4
21=	1191-1	1191-2	1191-3	1191-4	1191-5	115-1	115-2	115-3
31=	109-1	109-2	109-3	109-4	109-5	109-6	116-4	116-5
41=	118-2	118-3	118-4	118-5	118-6	117-4	117-5	117-6
51=	119-4	119-5	119-6	128-1	128-2	128-3	128-4	128-5
61=	120-2	120-3	120-4	120-5	120-6	121-1	121-2	121-4
71=	122-1	122-2	122-3	122-4	122-5	122-6	132-4	132-5
81=	123-5	123-6	124-1	124-2	124-3	124-4	124-5	124-6
91=	106-6	112-4	112-5	112-6	193-1	193-2	193-3	193-4
101=	192-2	192-3	192-4	192-5	192-6	191-1	191-2	191-3
111=	110-4	110-5	110-6	111-4	111-5	111-6	127-1	127-2
121=	127-5	136-1	136-2	136-3	136-4	136-5	136-6	126-1
131=	126-4	126-5	126-6	133-1	133-2	133-3	133-4	133-5
141=	137-4	137-5	137-6	129-1	129-2	129-3	129-4	129-5
151=	138-3	138-4	138-5	138-6	130-1	130-2	130-3	130-4
161=	131-1	131-2	131-3	131-4	131-5	141-4	141-5	141-6
171=	145-3	145-4	145-5	145-6	270-1	270-2	270-3	270-4
181=	273-1	273-2	273-3	273-4	273-5	273-6	271-1	271-2
191=	271-5	271-6	274-1	274-2	274-3	274-4	274-5	274-6
201=	125-6	134-1	134-2	134-3	134-4	134-5	134-6	254-1
211=	254-5	254-6	182-1	182-2	182-3	182-4	182-5	182-6
221=	190-3	190-4	190-5	190-6	189-1	189-2	189-3	189-4
231=	183-3	183-4	183-6	188-1	188-2	188-3	188-4	188-5
241=	187-2	187-3	187-4	187-6	186-1	186-2	186-3	186-4
251=	185-1	185-3	185-4	185-6	184-1	184-2	184-3	184-4
261=	144-2	144-3	144-4	144-5	135-4	135-5	135-6	143-4
271=	142-1	142-2	142-3	142-4	142-5	142-6	149-1	149-2
281=	149-5	149-6	146-1	146-2	146-3	146-4	146-5	139-1
291=	139-5	139-6	147-4	147-5	147-6	140-1	140-2	140-3
301=	140-6	150-4	150-5	150-6	1232-1	1232-2	1232-3	1232-4
311=	151-2	151-3	151-4	151-5	151-6	269-4	269-5	269-6
321=	272-6	255-2	255-3	255-5	255-6	256-1	256-2	256-3
331=	257-2	257-3	257-5	257-6	258-1	258-2	258-3	258-5
341=	249-2	249-3	249-5	249-6	250-1	250-2	250-3	250-5
351=	243-2	243-3	243-5	243-6	173-4	173-5	173-6	174-1
361=	174-6	181-4	181-5	181-6	180-1	180-2	180-3	180-4
371=	179-1	179-3	179-4	179-5	179-6	175-1	175-3	175-4
381=	177-3	177-4	177-5	177-6	178-1	178-2	178-3	178-4
391=	176-1	176-3	176-4	176-6	148-4	148-5	148-6	154-4

----- DSP ANALYSIS -----  
FREE-FREE MODES

AUGUST 24, 1983

ANALYSIS DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
1=	108-1	108-2	108-3	116-1	116-2	116-3	117-1	117-2
11=	121-3	132-1	132-2	132-3	123-1	123-2	123-3	106-1
21=	112-1	112-2	112-3	110-1	110-2	110-3	111-1	111-2
31=	141-1	141-2	141-3	125-1	125-2	125-3	183-2	185-2
41=	135-3	143-1	143-2	143-3	139-3	147-1	147-2	147-3
51=	150-3	269-1	269-2	269-3	272-1	272-2	272-3	255-1
61=	173-2	173-3	174-2	181-1	181-2	181-3	179-2	175-2
71=	148-1	148-2	148-3	154-1	154-2	154-3	376-1	376-2
81=	153-2	153-3	152-1	152-2	152-3	244-1	234-1	228-2
91=	377-3	226-2	156-2	1-1	1-2	1-3	37-1	37-2
101=	219-2	220-1	220-2	220-3	158-2	218-2	214-2	216-2
111=	15-2	15-3	261-1	261-2	261-3	264-1	264-2	264-3
121=	59-1	59-2	59-3	4-1	4-2	4-3	12-1	12-2
131=	12-5	12-6	9-1	9-2	9-3	7-1	7-2	7-3
141=	21-3	28-1	28-2	28-3	97-1	97-2	97-3	73-1
151=	199-2	94-1	94-2	94-3	19-1	19-2	19-3	105-1
161=	40-3	51-1	51-2	51-3	62-3	84-1	84-2	84-3
171=	90-3	102-1	102-2	102-3	100-1	100-2	100-3	47-1
181=	69-1	69-2	69-3	88-1	88-2	88-3	42-3	44-3
191=	55-2	55-3	66-3					

----- DSP ANALYSIS -----  
 FREE-FREE MODES

AUGUST 24, 1983

PERM SPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
1=	113-6	1191-5	115-6	193-5	191-5	127-6	133-6	129-6
11=	189-5	183-5	187-5	185-5	184-5	144-6	146-6	1232-5
21=	250-4	243-4	174-5	175-5	176-5	230-5	232-5	238-4
31=	253-4	244-4	239-4	165-5	166-5	171-5	169-5	167-5
41=	226-5	227-5	224-5	156-5	233-4	245-4	246-4	219-5
51=	157-5	158-5	162-5	160-5	218-5	217-5	13-6	14-6
61=	209-5	210-5	201-5	242-4	71-6	200-5	204-5	208-5
71=	50-6	83-6	72-6	199-5	82-6	237-4	17-6	18-6
81=	20-6	195-5	197-5	29-6	86-6	74-6	87-6	30-6
91=	32-6	93-6	52-6	75-6	92-6	89-6	57-6	80-6
101=	77-6	54-6						

BDRY SPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
1=	255-4	256-4	257-4	234-4	235-4	236-4		

APPENDIX C.      EXAMPLE OF A STATISTICAL CORRELATION REPORT

NASTRAN MODAL ANALYSIS - MODAL SURVEY STATISTICAL CORRELATION  
21-NOV-83

1. INTERACTIVE DIALOG:

IS A SEPARATE OUTPUT LISTING FILE TO BE PRINTED?(Y OR N): Y

ENTER ANALYTICAL LAMA MATRIX FILENAME: LAMA.TBL  
ENTER ANALYTICAL MODE-SHAPE MATRIX FILENAME: PHITE.MTX  
ENTER ANALYTICAL GRID POINT LIST FILENAME: GRDPTF.LIS

\*\*\*\* WARNING: UNEQUAL NUMBER OF FREQUENCIES AND MODE SHAPES.

NUMBER OF FREQUENCIES: 190  
NUMBER OF MODE SHAPES: 48  
ONLY THE FIRST 48 WILL BE USED.

ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : FMS001.AC2  
ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : FMS002.AC2  
ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : FMS003.AC2  
ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : FMS004.AC2  
ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : FMS005.AC2  
ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : FMS006.AC2  
ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : FMS007.AC2  
ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : FMS008.AC2  
ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ("NONE" IF NO MORE) : NONE

IS ANALYTICAL VS. EXPERIMENTAL SYMMETRY TO BE CONSIDERED? (Y OR N): N

PRINT ANALYTICAL MODE-SHAPE VECTORS? (Y OR N): N  
PRINT EXPERIMENTAL MODE-SHAPE VECTORS? (Y OR N): N

RELATIVE DEVIATIONS GREATER THAN A THRESHOLD VALUE WILL BE PRINTED.  
THE DEFAULT THRESHOLD IS 0.050  
ENTER DESIRED THRESHOLD. ", " FOR DEFAULT: 0.100

RELATIVE DEVIATIONS GREATER THAN 10.00 % WILL BE PRINTED.

ORIGINAL PAGE 19  
OF POOR QUALITY

NASTRAN MODAL ANALYSIS - MODAL SURVEY STATISTICAL CORRELATION  
21-NOV-83

2. SUMMARY OF FREQUENCY, MASS, STIFFNESS, DAMPING, AND SYMMETRY:

ANALYTICAL MODES:

MODE	FREQUENCY	MASS	STIFFNESS	SYMMETRY		
-----	-----	-----	-----	-----	-----	-----
1	4.78003426E+01	1.00000000E+00	9.02031563E+04	0	0	0
2	8.52370071E+01	9.9999881E-01	2.86824438E+05	0	0	0
3	8.92746735E+01	9.9999821E-01	3.14641656E+05	0	0	0
4	9.36831284E+01	9.9999940E-01	3.46483469E+05	0	0	0
5	1.14596474E+02	1.00000000E+00	5.18444500E+05	0	0	0
6	1.29791458E+02	1.00000000E+00	6.65046375E+05	0	0	0
7	1.42888336E+02	1.00000012E+00	8.06034125E+05	0	0	0
8	1.49144562E+02	1.00000000E+00	8.78161875E+05	0	0	0
9	1.51106857E+02	1.00000000E+00	9.01422000E+05	0	0	0
10	1.61486435E+02	1.00000000E+00	1.02951300E+06	0	0	0
11	1.66986420E+02	1.00000000E+00	1.10083463E+06	0	0	0
12	1.76361176E+02	1.00000012E+00	1.22790788E+06	0	0	0
13	1.86912598E+02	1.00000000E+00	1.37923075E+06	0	0	0
14	2.03151978E+02	9.9999940E-01	1.62930288E+06	0	0	0
15	2.13227921E+02	1.00000000E+00	1.79493163E+06	0	0	0
16	2.15393066E+02	1.00000012E+00	1.83156913E+06	0	0	0
17	2.20526611E+02	1.00000024E+00	1.91991450E+06	0	0	0
18	2.25210617E+02	9.9999821E-01	2.00233788E+06	0	0	0
19	2.28891800E+02	1.00000000E+00	2.06833200E+06	0	0	0
20	2.37163879E+02	9.9999940E-01	2.22053100E+06	0	0	0
21	2.41989059E+02	9.9999881E-01	2.31180500E+06	0	0	0
22	2.44966827E+02	1.00000000E+00	2.36905050E+06	0	0	0
23	2.46436966E+02	1.00000012E+00	2.39757125E+06	0	0	0
24	2.59525421E+02	9.9999881E-01	2.65900725E+06	0	0	0
25	2.67757904E+02	1.00000000E+00	2.83037750E+06	0	0	0
26	2.76532684E+02	9.9999762E-01	3.01892675E+06	0	0	0
27	2.77095856E+02	1.00000000E+00	3.03123675E+06	0	0	0
28	2.87656219E+02	1.00000012E+00	3.26668575E+06	0	0	0
29	2.98013702E+02	1.00000000E+00	3.50616400E+06	0	0	0
30	3.28465637E+02	9.9999940E-01	4.25931300E+06	0	0	0
31	3.31687805E+02	9.9999702E-01	4.34328750E+06	0	0	0
32	3.38717804E+02	9.9999881E-01	4.52934850E+06	0	0	0
33	3.46994293E+02	1.00000000E+00	4.75340050E+06	0	0	0
34	3.55755737E+02	9.9999940E-01	4.99647250E+06	0	0	0
35	3.83082672E+02	1.00000024E+00	5.79355150E+06	0	0	0
36	3.94640564E+02	1.00000000E+00	6.14841500E+06	0	0	0
37	4.00549103E+02	1.00000012E+00	6.33390250E+06	0	0	0
38	4.01798157E+02	9.9999821E-01	6.37346400E+06	0	0	0
39	4.11575165E+02	1.00000000E+00	6.68741200E+06	0	0	0
40	4.23178680E+02	9.9999940E-01	7.06980300E+06	0	0	0
41	4.62407135E+02	9.9999702E-01	8.44128800E+06	0	0	0
42	4.66884094E+02	1.00000000E+00	8.60553500E+06	0	0	0
43	4.73970062E+02	1.00000000E+00	8.86873200E+06	0	0	0
44	4.76452454E+02	1.00000024E+00	8.96187800E+06	0	0	0
45	4.87654266E+02	9.9999940E-01	9.38823100E+06	0	0	0
46	4.94913330E+02	1.00000000E+00	9.66981300E+06	0	0	0
47	5.04736725E+02	1.00000000E+00	1.00574890E+07	0	0	0
48	5.08807892E+02	1.00000012E+00	1.02203900E+07	0	0	0

EXPERIMENTAL MODES:

MODE	FREQUENCY	DAMPING	SYMMETRY		
1	6.911E+01	1.113E-02	0	0	0
2	7.811E+01	4.992E-03	0	0	0
3	9.535E+01	1.076E-02	0	0	0
4	1.130E+02	1.075E-02	0	0	0
5	1.645E+02	4.948E-03	0	0	0
6	2.258E+02	3.984E-03	0	0	0
7	2.280E+02	2.466E-03	0	0	0
8	3.617E+02	1.475E-03	0	0	0

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3. CORRELATION COEFFICIENTS FOR ANALYTICAL VS. EXPERIMENTAL COMPARISONS:

ANALYTICAL MODES	EXPERIMENTAL MODES							
	1	2	3	4	5	6	7	8
1	-0.506	-0.521	-0.473	-0.375	-0.201	0.248	0.327	0.716
2	-0.283	-0.294	-0.224	-0.106	0.049	0.324	0.452	0.515
3	-0.984	-0.841	-0.930	-0.982	-0.923	-0.016	0.016	0.172
4	-0.958	-0.989	-0.991	-0.920	-0.692	0.293	0.338	0.088
5	-0.952	-0.988	-0.984	-0.906	-0.670	0.325	0.372	0.095
6	-0.462	-0.413	-0.382	-0.304	-0.178	0.272	0.404	0.377
7	-0.996	-0.885	-0.957	-0.985	-0.889	0.041	0.078	0.167
8	-0.994	-0.905	-0.964	-0.971	-0.850	0.124	0.166	0.128
9	-0.942	-0.833	-0.913	-0.962	-0.889	-0.126	-0.109	0.341
10	-0.917	-0.754	-0.869	-0.961	-0.959	-0.041	-0.055	-0.027
11	0.971	0.803	0.901	0.966	0.929	0.045	0.011	-0.197
12	0.409	0.498	0.523	0.526	0.431	-0.076	0.007	0.451
13	0.186	0.408	0.260	0.029	-0.274	-0.919	-0.962	0.091
14	-0.035	-0.121	-0.149	-0.181	-0.176	0.009	-0.111	-0.596
15	0.106	0.186	0.219	0.253	0.238	0.026	0.135	0.575
16	0.109	0.189	0.222	0.257	0.242	0.063	0.169	0.534
17	0.722	0.451	0.618	0.803	0.941	0.561	0.545	-0.173
18	0.993	0.904	0.965	0.979	0.863	-0.093	-0.124	-0.192
19	0.961	0.839	0.898	0.910	0.808	-0.043	-0.118	-0.294
20	-0.862	-0.606	-0.749	-0.887	-0.963	-0.267	-0.238	0.159
21	-0.182	-0.178	-0.254	-0.348	-0.402	-0.289	-0.396	-0.312
22	0.078	0.117	0.028	-0.105	-0.246	-0.466	-0.576	-0.316
23	0.227	0.495	0.396	0.231	-0.038	-0.715	-0.647	0.506
24	0.142	0.198	0.243	0.295	0.297	0.153	0.264	0.364
25	-0.135	-0.167	-0.224	-0.296	-0.324	-0.224	-0.334	-0.337
26	-0.248	-0.389	-0.275	-0.088	0.154	0.871	0.912	-0.037
27	0.536	0.754	0.668	0.499	0.195	-0.753	-0.727	0.341
28	-0.109	-0.137	-0.197	-0.272	-0.310	-0.215	-0.327	-0.400
29	-0.212	-0.490	-0.343	-0.109	0.220	0.961	0.958	-0.326
30	-0.214	-0.471	-0.324	-0.092	0.228	0.969	0.979	-0.257
31	-0.230	-0.516	-0.359	-0.111	0.238	0.945	0.964	-0.255
32	0.306	0.427	0.431	0.410	0.304	-0.210	-0.101	0.397
33	0.120	0.025	0.008	-0.029	-0.043	-0.188	-0.306	-0.262
34	0.054	0.290	0.206	0.070	-0.131	-0.722	-0.649	0.815
35	0.248	0.209	0.273	0.356	0.400	0.346	0.431	-0.336
36	-0.426	-0.420	-0.426	-0.416	-0.333	-0.152	-0.149	0.756
37	0.176	0.409	0.271	0.051	-0.241	-0.986	-0.997	0.359
38	-0.916	-0.958	-0.939	-0.841	-0.592	0.380	0.455	0.070
39	0.290	0.308	0.339	0.375	0.338	0.473	0.494	-0.511
40	0.099	0.029	0.015	0.001	-0.013	0.270	0.172	-0.957
41	-0.236	-0.182	-0.200	-0.224	-0.211	-0.470	-0.423	0.943
42	0.133	0.143	0.138	0.140	0.096	0.486	0.447	-0.870
43	0.153	0.100	0.088	0.075	0.037	0.445	0.318	-0.950
44	0.318	0.208	0.265	0.336	0.381	0.371	0.384	-0.795
45	-0.202	-0.177	-0.179	-0.185	-0.146	-0.498	-0.433	0.946
46	-0.204	-0.178	-0.178	-0.181	-0.139	-0.496	-0.424	0.957
47	0.090	0.321	0.193	0.019	-0.254	0.002	-0.085	-0.660
48	0.078	-0.119	-0.009	0.128	0.336	-0.261	-0.140	0.547

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4. ANALYTICAL MODE SHAPES AND THEIR BEST EXPERIMENTAL MATCHES:

NASTRAN MODE	NASTRAN FREQUENCY	TEST MODE	TEST FREQUENCY	OF GP'S COMPARED	CORREL COEFF	MAX REL DIFFERENC	GRID POINT
1	47.80034	8	361.69601	5	0.716	1.007E+00	234
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)							
234-1/-1.007E+00 244-1/ 6.232E-01 245-1/ 5.158E-01 255-1/ 8.589E-01							
257-1/ 6.611E-01							
SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)							
234-1/-1.435E+00 244-1/ 8.821E-01 245-1/-7.546E-01 255-1/ 1.864E+00							
257-1/-1.582E+00							
2	85.23701	8	361.69601	5	0.515	1.507E+00	234
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)							
234-1/-1.507E+00 244-1/-2.875E-01 245-1/ 9.712E-01 255-1/ 1.245E+00							
SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)							
234-1/-1.273E+00 244-1/ 5.324E-01 245-1/-3.724E-01 255-1/ 1.536E+00							
3	89.27467	1	69.11099	5	-0.984	2.612E-01	257
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)							
244-1/ 1.297E-01 255-1/-2.471E-01 257-1/-2.612E-01							
SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)							
244-1/ 1.253E+02 255-1/ 2.709E+01 257-1/ 3.294E+01							
4	93.68313	3	95.35100	5	-0.991	2.363E-01	234
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)							
234-1/-2.363E-01 255-1/ 1.033E-01 257-1/ 1.507E-01							
SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)							
234-1/ 1.430E+01 255-1/ 2.584E+01 257-1/ 2.537E+01							
5	114.59647	2	78.10699	5	-0.988	1.978E-01	234
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)							
234-1/-1.978E-01 244-1/ 1.382E-01 245-1/ 1.853E-01 255-1/-1.350E-01							

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 1.738E+01 244-1/ 3.846E+01 245-1/ 3.990E+01 255-1/ 3.214E+01

6 129.79146 1 69.11099 5 -0.462 1.871E+00 244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-1.192E+00 244-1/-1.871E+00 245-1/ 5.432E-01 255-1/-3.838E-01  
 257-1/ 1.195E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-3.145E+00 244-1/-5.217E+00 245-1/ 1.041E+01 255-1/ 4.545E-01  
 257-1/ 3.925E+00

7 142.88834 1 69.11099 5 -0.996 1.320E-01 257

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 255-1/-1.081E-01 257-1/-1.320E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 255-1/ 6.456E+02 257-1/ 7.248E+02

8 149.14456 1 69.11099 5 -0.994 2.007E-01 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-2.007E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 1.003E+02

9 151.10686 4 112.99900 5 -0.962 4.537E-01 255

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 1.278E-01 245-1/ 1.950E-01 255-1/-4.537E-01 257-1/ 3.481E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-3.247E+00 245-1/-4.100E+00 255-1/-1.771E+00 257-1/-1.181E+00

10 161.48643 4 112.99900 5 -0.961 3.907E-01 257

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-3.256E-01 244-1/ 3.064E-01 255-1/-1.722E-01 257-1/-3.907E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-3.297E+00 244-1/-4.434E+00 255-1/-1.618E+00 257-1/-1.434E+00

11 166.98642 1 69.11099 5 0.971 3.647E-01 255

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 1.162E-01 245-1/-1.864E-01 255-1/ 3.647E-01 257-1/ 3.218E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-7.006E+01 245-1/-1.597E+02 255-1/-1.795E+01 257-1/-3.023E+01

12 176.36118 4 112.99900 5 0.526 2.016E+00 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 2.151E-01 244-1/-1.592E-01 245-1/ 2.016E+00 255-1/-5.754E-01  
 257-1/ 5.240E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 1.046E+00 244-1/ 1.452E+00 245-1/ 1.564E+00 255-1/ 4.019E-01  
 257-1/ 4.853E-01

13 186.91260 7 228.02299 5 -0.962 3.708E-01 257

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-1.529E-01 244-1/ 1.779E-01 245-1/-2.851E-01 255-1/ 3.233E-01  
 257-1/-3.708E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-4.837E+00 244-1/ 6.055E-02 245-1/ 6.729E-01 255-1/ 4.525E+00  
 257-1/ 3.404E+00

14 203.15198 8 361.69601 5 -0.596 1.464E+00 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 1.464E+00 244-1/ 7.515E-01 245-1/-7.987E-01 255-1/-5.376E-01  
 257-1/ 6.349E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 1.417E+00 244-1/-2.671E-01 245-1/ 2.323E-01 255-1/-1.368E+00  
 257-1/ 1.306E+00

15 213.22792 8 361.69601 5 0.575 1.626E+00 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-1.626E+00 244-1/-7.567E-01 245-1/ 6.682E-01 255-1/ 4.587E-01  
 257-1/-6.136E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-1.616E+00 244-1/-1.088E-01 245-1/ 6.512E-02 255-1/ 1.080E+00  
 257-1/-1.111E+00

16 215.39307 8 361.69601 5 0.534 1.726E+00 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-1.726E+00 244-1/-7.268E-01 245-1/ 6.917E-01 255-1/ 5.012E-01  
 257-1/-6.491E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-1.431E+00 244-1/ 2.724E-01 245-1/-2.675E-01 255-1/ 1.293E+00  
 257-1/-1.250E+00

17 220.52661 5 164.46001 5 0.941 4.653E-01 244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-3.993E-01 244-1/ 4.653E-01 257-1/ 4.484E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-1.385E+01 244-1/-9.189E+00 257-1/ 7.887E+00

18 225.21062 1 69.11099 5 0.993 1.503E-01 244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 1.279E-01 244-1/-1.503E-01 255-1/ 1.382E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-8.470E+01 244-1/-1.720E+02 255-1/-5.054E+01

19 228.89180 1 69.11099 5 0.961 4.079E-01 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 1.846E-01 244-1/ 3.802E-01 245-1/-4.079E-01 255-1/ 2.142E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-3.699E+01 244-1/-4.916E+01 245-1/-1.082E+02 255-1/-1.950E+01

20 237.16388 5 164.46001 5 -0.963 4.412E-01 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-1.440E-01 244-1/-3.758E-01 245-1/ 4.412E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 7.447E+00 244-1/ 1.071E+01 245-1/ 1.850E+01

21 241.98906 5 164.46001 5 -0.402 2.383E+00 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 1.136E-01 245-1/-2.383E+00 255-1/ 4.441E-01 257-1/-2.900E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 1.894E+01 245-1/-2.310E+01 255-1/ 5.374E+00 257-1/-9.868E+00

22      244.96683      7      228.02299      5      -0.576      1.290E+00      255

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)

234-1/-4.072E-01      244-1/ 1.069E+00      245-1/-1.123E+00      255-1/ 1.290E+00

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)

234-1/-1.553E+00      244-1/ 2.123E-01      245-1/ 1.399E-02      255-1/ 1.615E+00

23      246.43697      6      225.84801      5      -0.715      1.142E+00      234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)

234-1/-1.142E+00      244-1/-8.476E-01      245-1/ 8.765E-01      255-1/-2.123E-01

257-1/ 1.145E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)

234-1/-2.057E+00      244-1/-1.216E-01      245-1/ 3.905E-01      255-1/ 1.124E+00

257-1/ 1.002E+00

24      259.52542      8      361.69601      5      0.364      1.895E+00      234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)

234-1/-1.895E+00      244-1/-8.343E-01      245-1/ 7.344E-01      255-1/ 8.610E-01

257-1/-8.887E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)

234-1/-1.635E+00      244-1/-2.462E-01      245-1/ 1.926E-01      255-1/ 1.135E+00

257-1/-1.103E+00

25      267.75790      8      361.69601      5      -0.337      1.970E+00      234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)

234-1/ 1.970E+00      244-1/ 8.220E-01      245-1/-7.023E-01      255-1/-9.740E-01

257-1/ 7.927E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)

234-1/ 2.781E+00      244-1/ 1.894E+00      245-1/-1.668E+00      255-1/-7.808E-01

257-1/ 5.379E-01

26      276.53268      7      228.02299      5      0.912      6.383E-01      245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)

245-1/ 6.383E-01      255-1/-6.327E-01      257-1/ 2.610E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)

245-1/-4.325E-01      255-1/-3.131E+00      257-1/-2.387E+00

27      277.09586      2      78.10699      5      0.754      1.107E+00      234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% ; (GRID ID/DEVIATION)  
 234-1/ 1.107E+00 244-1/-1.991E-01 245-1/ 1.035E+00 255-1/-3.451E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD ; (GRID ID/DIFFERENCE)  
 234-1/ 4.357E+00 244-1/-9.549E+00 245-1/ 1.981E+00 255-1/-1.196E+01

28 287.65622 8 361.69601 5 -0.400 1.903E+00 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% ; (GRID ID/DEVIATION)  
 234-1/ 1.903E+00 244-1/ 8.008E-01 245-1/-6.998E-01 255-1/-9.072E-01  
 257-1/ 6.519E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD ; (GRID ID/DIFFERENCE)  
 234-1/ 4.232E+00 244-1/ 4.260E+00 245-1/-3.861E+00 255-1/ 2.393E-02  
 257-1/-6.488E-01

29 298.01370 6 225.84801 5 0.961 4.744E-01 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% ; (GRID ID/DEVIATION)  
 234-1/ 4.744E-01 244-1/ 1.119E-01 255-1/ 1.538E-01 257-1/ 3.453E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD ; (GRID ID/DIFFERENCE)  
 234-1/ 1.703E+00 244-1/ 4.127E-01 255-1/ 5.829E-01 257-1/ 1.277E+00

30 328.46564 7 228.02299 5 0.979 3.031E-01 257

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% ; (GRID ID/DEVIATION)  
 234-1/ 2.192E-01 244-1/ 2.321E-01 257-1/ 3.031E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD ; (GRID ID/DIFFERENCE)  
 234-1/ 2.075E+00 244-1/ 9.637E-01 257-1/ 3.996E-01

31 331.68781 7 228.02299 5 0.964 4.343E-01 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% ; (GRID ID/DEVIATION)  
 234-1/ 4.343E-01 244-1/ 1.634E-01 245-1/-1.717E-01 255-1/ 1.011E-01  
 257-1/ 3.285E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD ; (GRID ID/DIFFERENCE)  
 234-1/ 4.766E+00 244-1/ 1.005E-01 245-1/-8.296E-01 255-1/-4.088E+00  
 257-1/-3.117E+00

32 338.71780 3 95.35100 5 0.431 2.228E+00 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% ; (GRID ID/DEVIATION)  
 234-1/ 4.634E-01 244-1/-4.797E-01 245-1/ 2.228E+00 255-1/ 1.077E-01  
 257-1/ 5.222E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-5.728E-02    244-1/-2.912E+00    245-1/ 4.001E+00    255-1/-9.730E-01  
 257-1/ 1.745E-01

33      346.99429      7      228.02299      5      -0.306    1.561E+00      245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-6.545E-01    244-1/ 1.064E+00    245-1/-1.561E+00    255-1/ 1.459E+00  
 257-1/ 9.013E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-1.449E+00    244-1/ 8.258E-02    245-1/ 1.038E-01    255-1/ 1.403E+00  
 257-1/ 1.101E+00

34      355.75574      8      361.69601      5      0.815    1.242E+00      257

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-2.168E-01    244-1/-2.589E-01    245-1/ 2.124E-01    255-1/-3.909E-01  
 257-1/-1.242E+00

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-1.312E+00    244-1/ 5.981E-01    245-1/-5.989E-01    255-1/ 1.383E+00  
 257-1/-2.116E+00

35      383.08267      7      228.02299      5      0.431    1.747E+00      257

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 3.683E-01    244-1/-1.352E+00    245-1/ 6.752E-01    255-1/-4.676E-01  
 257-1/-1.747E+00

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 1.523E+00    244-1/-8.820E-02    245-1/-1.971E-01    255-1/-1.413E+00  
 257-1/-1.220E+00

36      394.64056      8      361.69601      5      0.756    1.308E+00      244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-1.235E-01    244-1/ 1.308E+00    245-1/-5.998E-01    255-1/ 3.757E-01  
 257-1/ 4.632E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-1.308E+00    244-1/ 1.115E+00    245-1/-9.107E-01    255-1/ 1.792E+00  
 257-1/-1.439E+00

37      400.54910      7      228.02299      5      -0.997    1.568E-01      244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)

244-1/-1.568E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
244-1/-1.598E-01

38 401.79816 2 78.10679 5 -0.958 4.568E-01 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/-3.745E-01 244-1/-2.143E-01 245-1/ 4.568E-01 257-1/-1.688E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
234-1/-2.346E-01 244-1/ 1.404E+00 245-1/ 5.543E+00 257-1/ 1.934E+00

39 411.57516 8 361.69601 5 -0.511 1.362E+00 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/-6.936E-01 244-1/-1.345E+00 245-1/ 1.362E+00 255-1/-7.729E-01  
257-1/ 3.877E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
234-1/ 4.946E-01 244-1/-1.005E+00 245-1/ 9.959E-01 255-1/-1.328E+00  
257-1/ 1.090E+00

40 423.17868 8 361.69601 5 -0.957 5.475E-01 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/ 5.475E-01 244-1/ 2.781E-01 245-1/-2.173E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
234-1/ 2.881E+00 244-1/-9.786E-01 245-1/ 1.014E+00

41 462.40714 8 361.69601 5 0.943 5.112E-01 244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/ 2.562E-01 244-1/ 5.118E-01 245-1/-4.861E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
234-1/ 2.506E+00 244-1/ 1.391E+00 245-1/-1.306E+00

42 466.88409 8 361.69601 5 -0.870 9.348E-01 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/-4.404E-01 244-1/-4.085E-01 245-1/ 9.348E-01 255-1/-2.553E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
234-1/-9.477E-01 244-1/-8.201E-01 245-1/ 1.908E+00 255-1/-4.763E-01

43 473.97006 8 361.69601 5 -0.950 5.011E-01 244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
244-1/ 5.011E-01 245-1/-3.250E-01 255-1/-3.669E-01 257-1/ 2.301E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
244-1/-1.464E-02 245-1/ 4.715E-01 255-1/-2.585E+00 257-1/ 2.183E+00

44 476.45245 8 361.69601 5 -0.795 1.302E+00 244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/ 1.234E-01 244-1/-1.302E+00 245-1/ 5.608E-01 255-1/ 1.600E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
234-1/ 1.174E+00 244-1/-1.387E+00 245-1/ 9.626E-01 255-1/-1.384E+00

45 487.65427 8 361.69601 5 0.946 5.167E-01 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/ 4.123E-01 244-1/ 2.499E-01 245-1/-5.167E-01 255-1/ 2.058E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
234-1/ 2.616E+00 244-1/ 4.199E-01 245-1/-1.514E+00 255-1/-4.404E-01

46 494.91333 8 361.69601 5 0.957 4.386E-01 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/ 4.023E-01 244-1/ 1.726E-01 245-1/-4.386E-01 255-1/ 2.224E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
234-1/ 1.448E+01 244-1/-3.542E+00 245-1/-3.938E-02 255-1/-9.586E+00

47 504.73672 8 361.69601 5 -0.660 1.438E+00 255

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
244-1/ 1.999E-01 245-1/ 1.002E+00 255-1/-1.438E+00 257-1/-5.369E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
244-1/-3.375E-01 245-1/ 1.033E+00 255-1/-1.835E+00 257-1/ 5.864E-01

48 508.80789 8 361.69601 5 0.547 1.649E+00 255

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
234-1/ 3.762E-01 244-1/-8.422E-01 245-1/-9.169E-01 255-1/ 1.649E+00  
257-1/-3.427E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-8.649E-01 244-1/ 3.842E-01 245-1/-7.889E-01 255-1/ 1.667E+00  
 257-1/-1.247E+00

NASTRAN MODAL ANALYSIS - MODAL SURVEY STATISTICAL CORRELATION  
 21-NOV-83

5. EXPERIMENTAL MODE SHAPES AND THEIR BEST ANALYTICAL MATCHES:

TEST MODE	TEST FREQUENCY	NASTRAN MODE	NASTRAN FREQUENCY	OF GP'S COMPARED	CORREL COEFF	MAX REL DIFFERENC	GRID POINT
1	69.11099	7	142.88834	5	-0.996	1.320E-01	257
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION) 255-1/-1.081E-01 257-1/-1.320E-01							
SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE) 255-1/ 6.456E+02 257-1/ 7.248E+02							
2	78.10699	4	93.68313	5	-0.989	1.799E-01	244
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION) 234-1/-1.252E-01 244-1/ 1.799E-01 245-1/ 1.545E-01 255-1/-1.372E-01 257-1/-1.226E-01							
SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE) 234-1/ 3.614E+01 244-1/ 6.954E+01 245-1/ 6.712E+01 255-1/ 5.687E+01 257-1/ 5.509E+01							
3	95.35100	4	93.68313	5	-0.991	2.363E-01	234
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION) 234-1/-2.363E-01 255-1/ 1.033E-01 257-1/ 1.507E-01							
SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE) 234-1/ 1.430E+01 255-1/ 2.584E+01 257-1/ 2.537E+01							
4	112.99900	7	142.88834	5	-0.985	2.519E-01	245
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION) 234-1/-2.369E-01 244-1/-1.197E-01 245-1/ 2.519E-01 257-1/ 1.145E-01							
SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE) 234-1/ 2.785E+00 244-1/ 6.626E+00 245-1/ 9.541E+00 257-1/ 3.460E+00							
5	164.46001	20	237.16388	5	-0.963	4.412E-01	245
RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION) 234-1/-1.440E-01 244-1/-3.758E-01 245-1/ 4.412E-01							

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 7.447E+00 244-1/ 1.071E+01 245-1/ 1.850E+01

6 225.84801 37 400.54910 5 -0.986 2.857E-01 245

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/-1.719E-01 244-1/ 1.032E-01 245-1/-2.857E-01 257-1/-1.082E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/-8.159E+00 244-1/ 1.411E+00 245-1/-2.381E-01 257-1/ 4.829E+00

7 228.02299 37 400.54910 5 -0.997 1.568E-01 244

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 244-1/-1.568E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 244-1/-1.598E-01

8 361.69601 40 423.17868 5 -0.957 5.475E-01 234

RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > 10.00% : (GRID ID/DEVIATION)  
 234-1/ 5.475E-01 244-1/ 2.781E-01 245-1/-2.173E-01

SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD : (GRID ID/DIFFERENCE)  
 234-1/ 2.881E+00 244-1/-9.786E-01 245-1/ 1.014E+00

# APPENDIX D.      FORTRAN SOURCE CODE LISTING (TESETDMI.FOR)

```

PROGRAM TESETDMI
C
C THIS PROGRAM WILL GENERATE THE TESET MATRIX DMI INPUT TO INSERT INTO
C THE NASTRAN BULK DATA, FOR USE IN PARTITIONING THE PHIG MATRIX TO
C OBTAIN THE PHITE MATRIX.
C INPUT FILES:
C     EXTERNAL GRIDPOINT AND DOF FILE - CONTAINS THE GRIDPOINT ID'S
C     AND THEIR ASSOCIATED DOF COMPONENTS. CREATED BY THE USER WITH
C     ALL ENTRIES IN LIST-DIRECTED (FREE-FIELD) FORMAT.
C     ENTRIES ARE INSERTED IN GPID,DOF PAIRS, ONE PAIR FOR EACH
C     GRIDPOINT AND DOF-COMPONENT WHICH IS INSTRUMENTED IN THE
C     MODAL SURVEY.
C
C     NASTRAN PRINT FILE WITH DIAG 21 OUTPUT.
C
C     PARAMETER (MAXMSDOF=1000) !MAXIMUM NO. OF MODAL SURVEY GPID-DOF'S
C
C     INTEGER GPLIST(MAXMSDOF), GPDOF(MAXMSDOF), INTDOF(MAXMSDOF)
C     INTEGER IDOF, EGP, EDOF, G
C     CHARACTER REC*120, MSG2118*52, ENDOF21*37
C     CHARACTER*40 D21FILE, MSGPFILE, DMIFILE
C
C     DATA MSG2118 /'*** USER INFORMATION MESSAGE 2118, SUBROUTINE GP4PRT'/
C     DATA ENDOF21 /' ---- C O L U M N   T O T A L S ----'/
C
C GET NASTRAN DIAG 21 PRINT FILE
C TYPE 1000, 'FILENAME OF NASTRAN PRINT FILE WITH DIAG 21:'
C ACCEPT 2000, D21FILE
C OPEN(UNIT=2,NAME=D21FILE,TYPE='OLD',READONLY)
C
C GET MODAL SURVEY GRID-POINT LIST FILE
C TYPE 1000, 'FILENAME OF MODAL SURVEY GRIDPOINT LIST:'
C ACCEPT 2000, MSGPFILE
C OPEN(UNIT=1,NAME=MSGPFILE,TYPE='OLD',READONLY)
C
C GET TESET DMI FILENAME
C TYPE 1000, 'FILENAME FOR TESET DMI BULK DATA RECORDS:'
C ACCEPT 2000, DMIFILE
C
C READ MODAL SURVEY GPID-DOF LIST
C READ(1,*,END=10) (GPLIST(I),GPDOF(I),I=1,MAXMSDOF)
10      CLOSE(UNIT=1)
C
C COUNT AND PACK MODAL SURVEY GPID-DOF'S
I = 1
DO WHILE (GPLIST(I) .NE. 0)
    GPLIST(I) = 10*GPLIST(I) + GPDOF(I)
    I = I+1
    IF (I .GT. MAXMSDOF) GOTO 20

```

```

END DO
20      NDOFS = I-1
C
C SORT GPID-DOF LIST
DO 100 I=1,NDOFS-1
DO 100 J=I+1,NDOFS
      IF (GPLIST(J) .LT. GPLIST(I))
1        CALL SWAP(GPLIST(I), GPLIST(J))
100      END DO
C
C FIND DIAG 21 IN PRINT FILE
DO WHILE (REC(1:52) .NE. MSG2118)
      READ(2,3000,END=910) REC
END DO
C
C MATCH INTERNAL DOF'S (FROM DIAG 21) WITH MODAL SURVEY GPID-DOF'S
DO 300 WHILE (REC(1:37) .NE. ENDOF21)
      READ(2,3000,END=920) REC
      IF (REC(35:35) .NE. '-') GOTO 300
      READ(REC,4000,ERR=300) IDOF,EGP,EDOF
      G = IDOF
      EGP = 10*EGP + EDOF      !PACK G.P. AND DOF
C          CHECK FOR EGP IN MODAL SURVEY LIST
      CALL BINSRCH( EGP,GPLIST,NDOFS,LOC )
      IF (LOC .NE. 0) INTDOF(LOC) = IDOF
300      END DO
      CLOSE(UNIT=2)
C
C SORT LISTS ON INTERNAL DOF VALUE
DO 400 I=1,NDOFS-1
DO 400 J=I+1,NDOFS
      IF (INTDOF(J) .LT. INTDOF(I)) THEN
          CALL SWAP( INTDOF(I), INTDOF(J) )
          CALL SWAP( GPLIST(I), GPLIST(J) )
      END IF
400      END DO
C
C UNPACK GPID-DOF'S
DO N=1,NDOFS
      GPDOF(N) = MOD( GPLIST(N), 10 )
      GPLIST(N) = GPLIST(N) / 10
END DO
C
C CHECK FOR G.P.'S WITHOUT INTERNAL DOF MATCH
N = 1
DO WHILE ((INTDOF(N) .EQ. 0) .AND. (N .LE. NDOFS))
      TYPE 5000, GPLIST(N), GPDOF(N)
      N = N+1
      IF (N .GT. MAXMSDOF) GOTO 500
END DO
500      IF (N .GT. NDOFS) THEN
          TYPE *, 'ERROR - NO INTERNAL DOF FOR ANY MODAL SURVEY POINT'

```

```

        STOP 'FORTRAN STOP -- EXECUTION ABORTED'
    END IF
    NSTART = N
C
C WRITE DMI BULK DATA RECORDS
    OPEN(UNIT=3,NAME=DMIFILE,TYPE='NEW',CARRIAGECONTROL='LIST')
    WRITE(3,6000) 0,2,1,1,G,1
    ISEQ = 1
    IF (NDOFS .GT. NSTART+2) THEN
        WRITE(3,7000) 1,
    1      (INTDOF(N),GPLIST(N),GPDOF(N),N=NSTART,NSTART+2), ISEQ
    ELSE
        NT = NDOFS - NSTART + 1
        WRITE(3,8000) 1,(INTDOF(N),GPLIST(N),GPDOF(N),N=NSTART,NDOF)
    END IF
    I = NSTART + 3
    DO WHILE (I .LE. NDOFS)
        IF (NDOFS .GT. I+3) THEN
            WRITE(3,9000) ISEQ,
    1      (INTDOF(N),GPLIST(N),GPDOF(N),N=I,I+3), ISEQ+1
            ISEQ = ISEQ + 1
        ELSE
            NT = NDOFS - I + 1
            WRITE(3,10000) ISEQ,
    1      (INTDOF(N),GPLIST(N),GPDOF(N),N=I,NDOFS)
        END IF
        I = I + 4
    END DO
    CLOSE(UNIT=3)
C
    STOP 'FORTRAN STOP -- PROCESSING COMPLETED'
C
910    TYPE *, 'NO DIAG 21 OUTPUT FOUND IN NASTRAN PRINT FILE.'
    STOP 'FORTRAN STOP -- EXECUTION ABORTED'
C
920    TYPE *, 'END-OF-FILE WHILE READING NASTRAN DIAG 21 OUTPUT'
    STOP 'FORTRAN STOP -- EXECUTION ABORTED'
C
1000   FORMAT(1X,A,' ',%)
2000   FORMAT(A)
3000   FORMAT(1X,A120)
4000   FORMAT(I22,I11,2X,I2)
5000   FORMAT(' WARNING - NO INTERNAL DOF FOR GRID POINT',I9,'-',I1)
6000   FORMAT('DMI',5X,'TESET',3X,I8,8X,2I8)
7000   FORMAT('DMI',5X,'TESET',3X,I8,3(I8,I6,'.',I1),'+TE',I5.5)
8000   FORMAT('DMI',5X,'TESET',3X,I8,<NT>(I8,I6,'.',I1))
9000   FORMAT('+TE',I5.5,4(I8,I6,'.',I1),'+TE',I5.5)
10000  FORMAT('+TE',I5.5,<NT>(I8,I6,'.',I1))
    END

```

```

SUBROUTINE BINSRCH(IV,LIST,L,LOC)
C
C PERFORM BINARY SEARCH FOR VALUE IV IN LIST.
C LIST MUST BE IN ASCENDING SORT.
C LOCATION OF IV IS RETURNED IN LOC.
C IF IV IS NOT FOUND, LOC=0 IS RETURNED.
C
  DIMENSION LIST(*)
C
  LOC = 0
  IF (L .LT. 1) RETURN
  LBTM = 1
  LTOP = L
C
  DO WHILE (LTOP-LBTM .GT. 1)
    LMID = (LBTM+LTOP) / 2
    IF (IV .LT. LIST(LMID)) THEN
      LTOP = LMID
    ELSE IF (IV .GT. LIST(LMID)) THEN
      LBTM = LMID
    ELSE
      LOC = LMID
      RETURN
    END IF
  END DO
C
  IF (IV .EQ. LIST(LBTM)) THEN
    LOC = LBTM
  ELSE IF (IV .EQ. LIST(LTOP)) THEN
    LOC = LTOP
  END IF
C
  RETURN
END

```

```

SUBROUTINE SWAP(I,J)
C
  K=I
  I=J
  J=K
  RETURN
END

```

# APPENDIX E.      FORTRAN SOURCE CODE LISTING (LAMA.FOR)

```

PROGRAM LAMATABLE
C
C   PARAMETER (MAXEIG = 300)
C
C   CHARACTER LAMA*8
C   REAL FREQ(MAXEIG),GMASS(MAXEIG),STIFF(MAXEIG),SYMM(3)
C   REAL REC2(7*MAXEIG)
C
C   DATA LUNP, LUNM  /1 , 2/  !! PUNCH AND MATRIX FILE LOG UNIT  'S
C
C   POSITION PUNCH FILE TO 1ST CARD OF RECORD 2 OF LAMA TABLE
C   CALL FINDREC2(LUNP,LAMA)
C   READ RECORD 2 OF LAMA TABLE INTO ARRAY REC2
C   CALL READREC2(REC2,NVALUES,LUNP,MAXEIG)
C   EXTRACT FREQUENCY, MASS, AND STIFFNESS VECTORS FROM REC2
C   NEIGENS = NVALUES/7
C   DO 100 I=1,NEIGENS
C       FREQ(I) = REC2(7*I-2)
C       GMASS(I) = REC2(7*I-1)
C       STIFF(I) = REC2(7*I)
100      CONTINUE
C   DO ASCENDING SORT OF FREQ VECTOR; SLAVE SORT MASS AND STIFF VECTORS
C   CALL SORT(NEIGENS,FREQ,GMASS,STIFF)
C   CHECK PUNCH FILE FOR SYMMETRY PARAMETERS
C   CALL READSYM(SYMM,LUNP)
C   CLOSE PUNCH FILE
C   CLOSE(UNIT=LUNP)
C   WRITE MATRIX FILE
C   CALL WRITEMTX(NEIGENS,FREQ,GMASS,STIFF,SYMM,LUNM,LAMA)
C   STOP
C   END

```

```

SUBROUTINE FINDREC2(LUNP,LAMA)
C
C CHARACTER PFILE*80,LAMA*8,LINE*80
C
C OPEN PUNCH FILE
10 TYPE 1000, 'ENTER INPUT PUNCH FILE NAME:'
ACCEPT 2000, PFILE
OPEN(UNIT=LUNP,NAME=PFILE,TYPE='OLD',READONLY,ERR=10)
C POSITION FILE TO LAMA TABLE
TYPE 1000, 'ENTER NAME OF LAMA TABLE:'
ACCEPT 3000, LAMA
DO 100 I=1,1000000
READ(LUNP,2000,END=125) LINE
IF ((LINE(1:4).EQ.'DTI*') .AND. (LINE(9:16).EQ.LAMA))
* GOTO 150 !! LAMA TABLE FOUND
100 CONTINUE
C TABLE NOT FOUND; START OVER
125 TYPE *, '**** LAMA TABLE NOT FOUND'
CLOSE(UNIT=LUNP)
GOTO 10
C POSITION PUNCH FILE TO RECORD 2 OF LAMA TABLE
150 DO 200 I=1,1000000
READ(LUNP,4000,END=225) LINE(1:24),IREC
IF ((LINE(1:4).EQ.'DTI*') .AND. (LINE(9:16).EQ.LAMA)
* .AND. (IREC.EQ.2)) GOTO 250 !! RECORD 2 FOUND
200 CONTINUE
C RECORD 2 NOT FOUND; START OVER
225 TYPE *, '**** RECORD 2 OF LAMA TABLE NOT FOUND'
CLOSE(UNIT=LUNP)
GOTO 10
C POSITION FILE TO REREAD 1ST CARD OF RECORD 2
250 BACKSPACE LUNP
RETURN
C
1000 FORMAT(1X,A30,1X,$)
2000 FORMAT(A80)
3000 FORMAT(A8)
4000 FORMAT(A24,I16)
END

```

```

SUBROUTINE READREC2(IREC2,NVALUES,LUNP,MAXEIG)
C
  INTEGER IREC2(7*MAXEIG),ITEMP(4)
  CHARACTER*6 CTEMP(4)
C
  READ 1ST CARD OF LAMA TABLE RECORD 2
  READ(LUNP,1000) IREC2(1),IREC2(2)
  NVALUES = 2
C
  READ REMAINING CARDS UNTIL 'ENDREC' FOUND
  DO 200 I=1,1000000
    READ(LUNP,2000,END=225) (CTEMP(J),ITEMP(J),J=1,4)
    DO 100 J=1,4
      IF (CTEMP(J).EQ. 'ENDREC') GOTO 250
      NVALUES = NVALUES + 1
      IREC2(NVALUES) = ITEMP(J)
      IF (CTEMP(J)(6:6).EQ. ' ')
        * IREC2(NVALUES) = -IREC2(NVALUES)
      IF (NVALUES.EQ. 7*MAXEIG) GOTO 225
100    CONTINUE
200    CONTINUE
C
  END OF RECORD 2 OF LAMA TABLE NOT FOUND
225  TYPE 3000, NVALUES
      PAUSE 'TYPE "CONTINUE" OR "STOP"'
C
  CHECK TO SEE IF OF RECORD 2 ENTRIES IS DIVISIBLE BY 7
250  IF (MOD(NVALUES,7).NE. 0) TYPE 4000, NVALUES
      RETURN
C
1000  FORMAT(40X,2I16)
2000  FORMAT(8X,4(A6,I10))
3000  FORMAT(1X,'*** WARNING: END OF RECORD 2 NOT REACHED.',
  *      /1X,'          NUMBER OF ENTRIES READ: ',I4)
4000  FORMAT(1X,'*** WARNING: OF RECORD 2 ENTRIES',I4,
  *      ' NOT DIVISIBLE BY 7')
  END

```

```

SUBROUTINE READSYM(SYMM,LUNP)
C
CHARACTER*80 RECORD
REAL SYMM(3)
LOGICAL LSYM1,LSYM2,LSYM3
C
REWIND LUNP  (START SEARCH FROM TOP OF FILE
C
SET SYMMETRY DEFAULTS
SYMM(1) = 0.0
SYMM(2) = 0.0
SYMM(3) = 0.0
C
SEARCH PUNCH FILE FOR SYMMETRY DEFINITION RECORDS
DO 100 I=1,1000000
  READ(LUNP,1000,END=150) RECORD
  IF (RECORD(21:28) .EQ. 'SYM1PLAN') THEN
    LSYM1 = .TRUE.
    DECODE(2,2000,RECORD(47:48)) SYMM(1)
    TYPE *, 'PLANE 1 SYMMETRY:', SYMM(1)
  ELSE IF (RECORD(21:28) .EQ. 'SYM2PLAN') THEN
    LSYM2 = .TRUE.
    DECODE(2,2000,RECORD(47:48)) SYMM(2)
    TYPE *, 'PLANE 2 SYMMETRY:', SYMM(2)
  ELSE IF (RECORD(21:28) .EQ. 'SYM3PLAN') THEN
    LSYM3 = .TRUE.
    DECODE(2,2000,RECORD(47:48)) SYMM(3)
    TYPE *, 'PLANE 3 SYMMETRY:', SYMM(3)
  END IF
100 CONTINUE
C
REPORT NON-DEFINED SYMMETRY
150 IF (.NOT. LSYM1) TYPE 3000, '1'
  IF (.NOT. LSYM2) TYPE 3000, '2'
  IF (.NOT. LSYM3) TYPE 3000, '3'
  RETURN
C
1000 FORMAT(A80)
2000 FORMAT(F2.0)
3000 FORMAT(1X,'PLANE ',A1,' SYMMETRY NOT SPECIFIED')
END

```

```

      SUBROUTINE SORT(N,FREQ,GMASS,STIFF)
C
      REAL FREQ(N),GMASS(N),STIFF(N)
C
C      PERFORM ASCENDING SORT OF FREQ VECTOR
C      SLAVE SORT GMASS AND STIFF VECTORS
C
      IF (N .EQ. 1) RETURN
C
      DO 100 I=1,N-1
      DO 100 K=I+1,N
      IF (FREQ(K) .LT. FREQ(I)) THEN
          TEMP = FREQ(I)
          FREQ(I) = FREQ(K)
          FREQ(K) = TEMP
          TEMP = GMASS(I)
          GMASS(I) = GMASS(K)
          GMASS(K) = TEMP
          TEMP = STIFF(I)
          STIFF(I) = STIFF(K)
          STIFF(K) = TEMP
      END IF
100    CONTINUE
      RETURN
      END

      SUBROUTINE WRITEMTX(N,FREQ,GMASS,STIFF,SYMM,LUNM,LAMA)
C
      CHARACTER MFILE*40,LAMA*8
      REAL FREQ(N),GMASS(N),STIFF(N),SYMM(3)
C
C      OPEN MATRIX FILE
C      TYPE 1000, 'ENTER OUTPUT MATRIX FILENAME:'
      ACCEPT 2000, MFILE
      OPEN(UNIT=LUNM,NAME=MFILE,TYPE='NEW',
          *      CARRIAGECONTROL='LIST')
C      WRITE MATRIX FILE HEADER
      IROWS = N
      JCOLS = 6
      WRITE(LUNM,3000) LAMA,IROWS,JCOLS
C      WRITE VECTORS AS THREE COLUMNS OF MATRIX
      WRITE(LUNM,4000) FREQ      || COLUMN 1
      WRITE(LUNM,4000) GMASS     || COLUMN 2
      WRITE(LUNM,4000) STIFF     || COLUMN 3
      WRITE(LUNM,4000) (SYMM(1),I=1,N) || COLUMN 4
      WRITE(LUNM,4000) (SYMM(2),I=1,N) || COLUMN 5
      WRITE(LUNM,4000) (SYMM(3),I=1,N) || COLUMN 6
      CLOSE(UNIT=LUNM)
      RETURN
C
1000  FORMAT(1X,A30,1X,$)
2000  FORMAT(A40)
3000  FORMAT(A8,2I8)
4000  FORMAT(1PE16.8)
      END

```

# APPENDIX F.      FORTRAN SOURCE CODE LISTING (UNPACKDMI.FOR)

```

PROGRAM UNPACKDMI
C
  PARAMETER (MAXMTXSIZ = 100000)
  CHARACTER MATNAM*8, FLAG*1, CONTID*3
  REAL ARRAY(MAXMTXSIZ)
  LOGICAL ALL, EOF
  DATA LUN / 10 /

C
  DO 500 NFILE=1,1000000
C
    GET NEXT FILENAME
    CALL GETFIL(LUN,*499)
    ALL = .FALSE.
    EOF = .FALSE.
C
  DO 400 NMATRX=1,1000000
C
    GET NEXT MATRIX NAME
    IF (.NOT. ALL) THEN
      TYPE 1000
      ACCEPT 2000, MATNAM
      IF (MATNAM.EQ. '*ALL') ALL = .TRUE.
      END IF
C
      SEARCH FILE FOR MATRIX AND GET DIMENSIONS
      CALL FNDMTX(MATNAM,MROWS,NCOLS,CONTID,LUN,ALL,EOF)
      IF (EOF) GOTO 399
      IF (MROWS*NCOLS.GT. MAXMTXSIZ) THEN
        TYPE *, 'MATRIX IS TOO LARGE', MATNAM,MROWS,NCOLS
        TYPE *, 'INCREASE PARAMETER MAXMTXSIZ IN UNPACKDMI'
        GOTO 399
      ENDIF
C
      UNPACK MATRIX INTO ARRAY
      CALL UNPACK(ARRAY,MROWS,NCOLS,CONTID,LUN,ALL,EOF)
C
      REDUCE SQUARE DIAGONAL MATRIX TO VECTOR ?
      IF (MROWS.EQ. NCOLS) THEN
        TYPE 6000, MATNAM
        ACCEPT 4000, FLAG
        IF (FLAG.EQ. 'Y')
          * CALL REDUCE(MATNAM,ARRAY,MROWS,NCOLS)
          END IF
C
        WRITE UNPACKED MATRIX TO NEW FILE
        CALL WRTMTX(MATNAM,ARRAY,MROWS,NCOLS)
C
        IS ANOTHER MATRIX IN THIS FILE DESIRED ?
        IF (ALL.AND. EOF) GOTO 450
399  IF (.NOT. ALL) THEN
      TYPE 3000
      ACCEPT 4000, FLAG
      IF (FLAG.NE. 'Y') GOTO 450
      END IF
C
      CONTINUE
400  NO MORE MATRICES DESIRED FROM THIS FILE
C
450  CLOSE (UNIT=LUN)

```

```

C          IS ANOTHER FILE DESIRED ?
499          TYPE 5000
          ACCEPT 4000, FLAG
          IF (FLAG .NE. 'Y') GOTO 550
500          CONTINUE
550          STOP 'NO MORE FILES REQUESTED.'
C
1000         FORMAT(' ENTER MATRIX NAME. ("*ALL" FOR ALL MATRICES): ', $)
2000         FORMAT(A8)
3000         FORMAT(' DO YOU WANT ANOTHER MATRIX IN THIS FILE ? (Y OR N): ', $)
4000         FORMAT(A1)
5000         FORMAT(' DO YOU WANT ANOTHER FILE ? (Y OR N): ', $)
6000         FORMAT(' REDUCE DIAG MATRIX ', A8, ' TO A VECTOR ? (Y OR N): ', $)
          END

```

```

          SUBROUTINE FNDMTX(MATNAM, MROWS, NCOLS, CONTID, LUN, ALL, EOF)
C
          CHARACTER MATNAM*8, RECORD*80, FLD1TO3*24, CONTID*3
          LOGICAL ALL, EOF
C
          IF (.NOT. ALL) THEN
              REWIND LUN
              EOF = .FALSE.
          END IF
C
          SEARCH FOR DESIRED MATRIX AND GET DIMENSIONS
C
          FLD1TO3 = 'DMI' // MATNAM // '0'
          DO 100 I=1, 1000000
              READ(LUN, 1000, END=199) RECORD
              IF (ALL) FLD1TO3(9:16) = RECORD(9:16)
              IF (RECORD(1:24) .EQ. FLD1TO3) THEN
                  IF (ALL) MATNAM = RECORD(9:16)
                  READ(RECORD, 2000) MROWS, NCOLS, CONTID
                  CONTID(1:1) = '*'
                  GOTO 150
              ENDIF
100          CONTINUE
150          RETURN
C
          END OF FILE; NEXT MATRIX NOT FOUND
199          EOF = .TRUE.
          IF (ALL) TYPE *, 'END OF FILE REACHED'
          IF (.NOT. ALL) TYPE *, MATNAM, 'MATRIX HEADER CARD NOT FOUND'
          RETURN
C
1000         FORMAT(A80)
2000         FORMAT(56X, 2I8, A3)
          END

```

C-2

```

        SUBROUTINE GETFIL(LUN,*)
C
        CHARACTER FILNAM*40
C
C      GET NEXT FILENAME
        TYPE 1000
        ACCEPT 2000, FILNAM
C      OPEN FILE
        OPEN(UNIT=LUN,NAME=FILNAM,TYPE='OLD',READONLY,ERR=199)
        RETURN
C
C      NEW DMI FILE NOT FOUND
199      TYPE *, FILNAM, 'FILE NOT FOUND'
        RETURN 1
C
1000  FORMAT(' ENTER NAME OF NEXT DMI FILE: ', $)
2000  FORMAT(A40)
        END

```

```

        SUBROUTINE REDUCE(MATNAM,MATRIX,MROWS,NCOLS)
C
        CHARACTER*8 MATNAM
        REAL MATRIX(MROWS,NCOLS)
C
C      CHECK FOR SQUARE MATRIX
        IF (MROWS .NE. NCOLS) THEN
            TYPE *, MATNAM, 'NOT A SQUARE MATRIX. NO REDUCTION DONE.'
            RETURN
        ENDIF
C
C      REDUCE TO (1 X NCOL) ROW VECTOR USING DIAGONAL VALUES
        DO 100 N=1,NCOLS
            MATRIX(N,1) = MATRIX(N,N)
100      CONTINUE
        MROWS = 1
        RETURN
        END

```

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SUBROUTINE UNPACK(MATRIX,MROWS,NCOLS,CONTID,LUN,ALL,EOF)
C
CHARACTER*72 RECORD
CHARACTER*16 FLDID(2:5), CARDID*8, CONTID*3
EQUIVALENCE ( RECORD(1:1), CARDID(1:1) )
EQUIVALENCE ( RECORD(9:9), FLDID(2)(1:1) )
CHARACTER*6 FMT(6), REAL, INTGR, BLANK
REAL MATRIX(MROWS,NCOLS)
LOGICAL ALL, EOF
DIMENSION VALUE(4), IVALUE(4)
EQUIVALENCE (VALUE(1), IVALUE(1))
DATA FMT(1)/'(8X, '// , FMT(6)/'(8X) '//
DATA REAL/'E16.8, '// , INTGR/'I16, '// , BLANK/'A16, '//
C
C ZERO THE MATRIX
DO 100 I=1,MROWS
DO 100 J=1,NCOLS
MATRIX(I,J) = 0.0
100 CONTINUE
C
C PROCESS THE DMI CARDS FOR THIS MATRIX
DO 400 K=1,1000000
READ(LUN,1000,END=425) CARDID,FLDID
IF (CARDID .EQ. 'DMI ' ) THEN
C THIS IS HEADER CARD OF NEXT MATRIX; THIS MATRIX DONE.
IF (ALL) BACKSPACE LUN
GOTO 450
ELSE IF (CARDID .EQ. 'DMI* ' ) THEN
C THIS IS A COLUMN IDENTIFIER CARD
READ(RECORD,2000) JCOL,IROW,VALUE(1)
MATRIX(IROW,JCOL) = VALUE(1)
IROW = IROW + 1
ELSE IF (CARDID(1:3) .EQ. CONTID) THEN
C THIS IS A ROW/VALUE CARD
C DETERMINE TYPE OF CONTENTS IN FIELDS 2:5
DO 200 L=2,5
IF (FLDID(L)(13:13) .EQ. 'E') THEN
FMT(L) = REAL
ELSE IF (FLDID(L)(16:16) .EQ. ' ') THEN
FMT(L) = BLANK
ELSE
FMT(L) = INTGR
ENDIF
200 CONTINUE
C READ CARD IN APPROPRIATE FORMAT
READ(RECORD,FMT,ERR=201) VALUE
C PROCESS FIELDS 2:5
DO 300 L=2,5
IF (FMT(L) .EQ. REAL) THEN
MATRIX(IROW,JCOL) = VALUE(L-1)
IROW = IROW + 1
ELSE IF (FMT(L) .EQ. INTGR) THEN

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      IROW = IVALUE(L-1)
      ELSE IF (FMT(L) .EQ. BLANK) THEN
        CONTINUE
      ENDIF
300      CONTINUE
      ELSE
C        THIS IS A NON-DMI CARD; THIS MATRIX DONE
          READ(RECORD,1000)CARDID,FLDID
          GOTO 450
      ENDIF
400      CONTINUE
C      END OF FILE
425      EOF = .TRUE.
C      END OF MATRIX
450      RETURN
C
1000     FORMAT(A8,4A16)
2000     FORMAT(24X,2I16,E16.8)
      END

```

```

      SUBROUTINE WRTMTX(MATNAM,MATRIX,MROWS,NCOLS)
      CHARACTER MATNAM*8, NAME*12
      REAL MATRIX(MROWS,NCOLS)
C
      NAME = MATNAM//'.MTX'
      OPEN(UNIT=50,NAME=NAME,TYPE='NEW',CARRIAGECONTROL='LIST')
C      WRITE HEADER RECORD TO ASCII FILE
      WRITE(50,1000) MATNAM, MROWS, NCOLS
C      WRITE MATRIX TO ASCII FILE ( 1 VALUE PER RECORD )
      WRITE(50,2000) MATRIX
      CLOSE (UNIT=50)
      TYPE *, 'MATRIX FILE WRITTEN WITH MROWS, NCOLS:'
      TYPE *, NAME, MROWS, NCOLS
      RETURN
C
1000     FORMAT(A8,2I8)
2000     FORMAT(1PE16.8)
      END

```

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APPENDIX G. FORTRAN SOURCE CODE LISTING (GRDPTLST.FOR)

```

PROGRAM GRDPTLST
C
C THIS PROGRAM WILL READ THE TESET (DOF ID VS. GRID POINT ID)
C MATRIX FILE OBTAINED FROM THE NASTRAN PUNCH FILE AND GENERATE
C A GRID POINT ID LIST FILE, USING THE NON-ZERO ENTRIES OF THE
C TESET MATRIX.
C
C CHARACTER*35 MTXFIL, GPFIL, MTXNAME*8
C
C GET TESET MATRIX FILENAME
10 TYPE 1000, 'ENTER GRID POINT ID MATRIX FILENAME:'
ACCEPT 2000, MTXFIL
OPEN(UNIT=1,NAME=MTXFIL,TYPE='OLD',READONLY,ERR=10)
READ(1,3000) MTXNAME, MROWS, NCOLS
IF (NCOLS .NE. 1) STOP 'ERROR: SHOULD BE ONLY ONE COLUMN'
C GET GRID POINT LIST FILENAME
TYPE 1000, 'ENTER GRID POINT ID OUTPUT LIST FILENAME:'
ACCEPT 2000, GPFIL
OPEN(UNIT=2,NAME=GPFIL,TYPE='NEW',CARRIAGECONTROL='LIST')
C GENERATE LIST FILE FROM NON-ZERO MATRIX ENTRIES
NIDS = 0
DO 100 MDOF=1,MROWS
  READ(1,5000) GRDPT
  IF (GRDPT .NE. 0.0) THEN
    IGRDPT = INT(GRDPT)
    COMP = GRDPT - FLOAT(IGRDPT)
    ICOMP = NINT(10.0*COMP)
    IF (ICOMP .GT. 6) THEN
      IGRDPT = IGRDPT + 1
      ICOMP = 0
    END IF
    WRITE(2,6000) IGRDPT, ICOMP, MDOF
    NIDS = NIDS + 1
  END IF
100 CONTINUE
  CLOSE(UNIT=1)
  CLOSE(UNIT=2)
  TYPE *, NIDS, 'ENTRIES WRITTEN TO GRID POINT LIST'
  STOP
C
1000 FORMAT(1X,A44,1X,$)
2000 FORMAT(A35)
3000 FORMAT(A8,2I8)
4000 FORMAT(1X,A8,' IS A ',I8,' ROW BY ',I8,' COLUMN MATRIX')
5000 FORMAT(E16.8)
6000 FORMAT(I8,'-',I1,I12)
END

```

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APPENDIX H. FORTRAN SOURCE CODE LISTING (STATCORR.FOR)

```

C      PROGRAM STATCORR

      PARAMETER (MAXMODE= 200)
      PARAMETER (MAXDOF = 1000)
      COMMON /LIMITS/ MXMD,MXDF
      DATA MXMD/MAXMODE/, MXDF/MAXDOF/

C
      REAL FREQAN(MAXMODE), FREQEX(MAXMODE)
      REAL DISPAN(MAXDOF,MAXMODE), DISPEX(MAXDOF,MAXMODE)
      REAL MASS(MAXMODE),STIFF(MAXMODE),DAMP(MAXMODE)
      REAL CORREL(MAXMODE,MAXMODE), C(MAXMODE,MAXMODE)
      REAL S(MAXMODE,MAXMODE)
      REAL RMSA(MAXMODE,MAXMODE), RMSE(MAXMODE,MAXMODE)
      REAL AVECT(MAXDOF),EVECT(MAXDOF),DIFF(MAXDOF),DIFABS(MAXDOF)
      INTEGER IDDOFA(MAXDOF,MAXMODE),IDDOFE(MAXDOF,MAXMODE)
      INTEGER ICOMPA(MAXDOF,MAXMODE), ICOMPE(MAXDOF,MAXMODE)
      INTEGER NDOFA(MAXMODE), NDOFE(MAXMODE)
      INTEGER IDDOFI(MAXDOF),ICOMPI(MAXDOF)
      INTEGER NAFIT(MAXMODE),MEFIT(MAXMODE)
      INTEGER ASYMM(3,MAXMODE),ESYMM(3,MAXMODE)
      CHARACTER*10 AHEADER(4),EHEADER(4),HEADER(32)
      CHARACTER*9 CDATE
      CHARACTER*1 YESNO
      LOGICAL PRTAN,PRTEX,LSYMM,LPRINT

C
      COMMON /WHEN/ CDATE

C
      DATA PRTAN,PRTEX,LSYMM,LPRINT/4*.FALSE./
      DATA AHEADER/2*' NASTRAN',2*' TEST'/
      DATA EHEADER/2*' TEST', 2*' NASTRAN'/
      DATA HEADER/' OF GP'S', ' CORREL', 2*' ', 2*' RMS',
*      ' MAX REL', ' GRID', ' MODE', ' FREQUENCY',
*      ' MODE', ' FREQUENCY', ' COMPARED', ' COEFF',
*      ' CA', ' S', '(NASTRAN)', '(TEST)',
*      ' DIFFERENCE', ' POINT', 12*' _____'/'

C
      PRINT SECTION 1 HEADER
      CALL DATE(CDATE)
      PRINT 8000, CDATE
      PRINT 4000

C
      CHECK FOR SEPARATE PRINT FILE
      TYPE 5000
      ACCEPT 7000, YESNO
      IF (YESNO.EQ. 'Y') LPRINT = .TRUE.
      IF (LPRINT) PRINT 5500, YESNO

C
      GET ANALYTICAL FREQ, MASS, STIFFNESS, MODE-SHAPE, AND DOF LISTS
      CALL GETAN(FREQAN,MASS,STIFF,ASYMM,DISPAN,NAN,
*      IDDOFA,ICOMPA,NDOFA,LPRINT)

C
      GET EXPERIMENTAL FREQ, DAMPING, MODE-SHAPE, AND DOF LISTS

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CALL GETEXP(FREQEX,DAMP,ESYMM,DISPEX,MEX,IDDOFE,ICOMPE,
*                                NDOFE,LPRINT)
C   DETERMINE SYMMETRY, MODE-SHAPE DUMP, AND THRESHOLD OPTIONS
CALL OPTIONS(LSYMM,PRTRAN,PRTEX,RTHRESH,LPRINT)
C   PRINT INPUT SUMMARY
CALL INPSUM(NAN,FREQAN,MASS,STIFF,ASYMM,MEX,FREQEX,DAMP,ESYMM)
C   SORT DOF LISTS AND MODE SHAPE MATRICES (BASED ON DOF SORT)
CALL DOFSORT(IDDOFA,ICOMPA,NDOFA,DISPAN,NAN)
CALL DOFSORT(IDDOFE,ICOMPE,NDOFE,DISPEX,MEX)
C   COMPUTE CORRELATION COEFFICIENTS AND RMS VALUES FOR ALL
C   POSSIBLE ANALYTICAL/EXPERIMENTAL PAIRS
DO 100 N=1,NAN
DO 100 M=1,MEX
C   GET VECTORS TO BE COMPARED AND THEIR DOF INTERSECTION SET
CALL GETVEC(DISPAN(1,N),NDOFA(N),AVECT)
CALL GETVEC(DISPEX(1,M),NDOFE(M),EVECT)
CALL INTERSECT(AVECT,EVECT,IDDOFA(1,N),IDDOFE(1,M),
*                                ICOMPA(1,N),ICOMPE(1,M),
*                                NDOFA(N),NDOFE(M),IDDOFI,ICOMPI,NDOFI,
*                                ASYMM(1,N),ESYMM(1,M),LSYMM)
C   COMPUTE CORR COEFFS AND RMS VALUES FOR THIS PAIR
CALL CORRMS(AVECT,EVECT,NDOFI,CORREL(N,M),
*                                C(N,M),S(N,M),RMSA(N,M),RMSE(N,M))
100 CONTINUE
C   PRINT CORRELATION COEFFICIENT TABLE
CALL CORRTBL(CORREL,NAN,MEX)
C   DETERMINE BEST MATCH FOR EACH EXPERIMENTAL AND ANALYTICAL MODE
CALL MATCH(CORREL,NAN,MEX,NAFIT,MEFIT)
C   FOR EACH MATCHED PAIR, GET X/RMS DIFFERENCES AND PRINT SUMMARY
C   PRINT ANALYTICAL MODE SHAPE HEADER
PRINT 8000, CDATE
PRINT 1000, AHEADER,HEADER
DO 200 N=1,NAN
M = NAFIT(N)
C   GET VECTORS TO BE COMPARED AND THEIR DOF INTERSECTION SET
CALL GETVEC(DISPAN(1,N),NDOFA(N),AVECT)
CALL GETVEC(DISPEX(1,M),NDOFE(M),EVECT)
CALL INTERSECT(AVECT,EVECT,IDDOFA(1,N),IDDOFE(1,M),
*                                ICOMPA(1,N),ICOMPE(1,M),
*                                NDOFA(N),NDOFE(M),IDDOFI,ICOMPI,NDOFI,
*                                ASYMM(1,N),ESYMM(1,M),LSYMM)
C   CALCULATE INDIVIDUAL DIFFERENCES
CALL RMSDIFF(AVECT,EVECT,NDOFI,RMSA(N,M),RMSE(N,M),
*                                CORREL(N,M),S(N,M),DIFF,DIFABS)
C   PRINT SUMMARY FOR THIS PAIR, WITH MAX DIFF AND > THRESHOLD
CALL PRINT(N,FREQAN(N),M,FREQEX(M),NDOFI,CORREL(N,M),
*                                C(N,M),S(N,M),RMSA(N,M),RMSE(N,M),
*                                DIFF,DIFABS,IDDOFI,ICOMPI,RTHRESH)
200 CONTINUE
C   PRINT EXPERIMENTAL MODE SHAPE HEADER
PRINT 8000, CDATE
PRINT 3000, EHEADER,HEADER

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DO 300 M=1,MEX
  N = MEFIT(M)
C      GET VECTORS TO BE COMPARED AND THEIR DOF INTERSECTION SET
      CALL GETVEC(DISPEX(1,M),NDOFE(M),EVECT)
      CALL GETVEC(DISPAN(1,N),NDOFA(N),AVECT)
      CALL INTERSECT(AVECT,EVECT,IDDOFA(1,N),IDDOFE(1,M),
        *          ICOMPA(1,N),ICOMPE(1,M),
        *          NDOFA(N),NDOFE(M),IDDOFI,ICOMPI,NDOFI,
        *          ASYMM(1,N),ESYMM(1,M),LSYMM)
C      CALCULATE COMBINED RMS AND INDIVIDUAL DIFFERENCES
      CALL RMSDIFF(AVECT,EVECT,NDOFI,RMSA(N,M),RMSE(N,M),
        *          CORREL(N,M),S(N,M),DIFF,DIFABS)
C      PRINT SUMMARY FOR THIS PAIR, WITH MAX DIFF > THRESHOLD
      CALL PRINT(M,FREQEX(M),N,FREQAN(N),NDOFI,CORREL(N,M),
        *          C(N,M),S(N,M),RMSA(N,M),RMSE(N,M),
        *          DIFF,DIFABS,IDDOFI,ICOMPI,RTHRESH)
300    CONTINUE
C      PRINT ANALYTICAL AND/OR EXPERIMENTAL MODE-SHAPE VECTORS
      CALL PRINTPHI(NAN,NDOFA,IDDOFA,ICOMPA,DISPAN,PRTRAN,
        *          MEX,NDOFE,IDDOFE,ICOMPE,DISPEX,PRTEX)
      STOP 'FORTRAN STOP -- PROCESSING COMPLETED'
C
1000  FORMAT(1H0,'4. ANALYTICAL MODE SHAPES AND THEIR BEST',
  *        ' EXPERIMENTAL MATCHES:',/'0',12(A10,1X),2(/12(1X,A10)))
3000  FORMAT(1H0,'5. EXPERIMENTAL MODE SHAPES AND THEIR BEST',
  *        ' ANALYTICAL MATCHES:',/'0',12(A10,1X),2(/12(1X,A10)))
4000  FORMAT(1H0,' 1. INTERACTIVE DIALOG:')
5000  FORMAT(/,' IS A SEPARATE OUTPUT LISTING FILE TO BE PRINTED?',
  *        '(Y OR N): ', $)
5500  FORMAT(/,' IS A SEPARATE OUTPUT LISTING FILE TO BE PRINTED?',
  *        '(Y OR N): ', A1)
7000  FORMAT(A1)
8000  FORMAT(1H1,'NASTRAN MODAL ANALYSIS - MODAL SURVEY STATISTICAL',
  *        ' CORRELATION', /1X,A9)
      END

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C      SUBROUTINE CORRMS(AVECT,EVECT,NDOFI,CORREL,CA,S,RMSA,RMSE)
C
C      COMPUTE CORRELATION COEFFICIENTS AND RMS VALUES
C
C      REAL AVECT(*),EVECT(*)
C
C      INITIALIZE RMS'S AND CORR COEFFS
RMSA = 0.0
RMSE = 0.0
CORREL = 0.0
CA = 0.0
S = 0.0
      IF (NDOFI .EQ. 0) RETURN
C      COMPUTE VARIANCES OF ANALYTICAL AND EXPERIMENTAL VECTORS
C      NOTE: THE FINAL VALUES COMPUTED HERE FOR THE "VARIANCES"
C      ARE NOT TRUE VARIANCES. TO OBTAIN VARIANCES, THE VALUES
C      VARA, VARE, AND VARAE SHOULD BE EACH MULTIPLIED BY 1/NDOFI .
C      THESE VALUES ARE NOT REPORTED, BUT ARE USED ONLY TO
C      CALCULATE CORREL, CA, S, RMSA, AND RMSE. THE 1/NDOFI FACTOR
C      IS NOT INCLUDED, SINCE IT APPEARS IN BOTH THE NUMERATOR AND
C      DENOMINATOR OF CORREL AND CA; THE EXTRA ARITHMETIC OPERATIONS
C      WOULD SIMPLY INTRODUCE UNNECESSARY ERROR IN THE RESULTS.
C      THE 1/NDOFI FACTOR IS INCLUDED IN THE CALCULATIONS OF
C      S, RMSA, AND RMSE.
VARA = 0.0
VARE = 0.0
VARAE = 0.0
DO 100 N=1,NDOFI
      VARA = VARA + AVECT(N)*AVECT(N)
      VARE = VARE + EVECT(N)*EVECT(N)
      VARAE = VARAE + AVECT(N)*EVECT(N)
100    CONTINUE
C      COMPUTE CORRELATION COEFFICIENT FOR THIS PAIR OF VECTORS
C      IF (VARAE .NE. 0.0) CORREL = VARAE/SQRT(VARA*VARE)
C      COMPUTE CORREL COEFF (REFERENCED TO ANALYTICAL VECTOR)
C      IF (VARA .NE. 0.0) CA = VARAE/VARA
C      COMPUTE ROOT OF MEAN SQUARE DIFFERENCE
S = SQRT( ABS(VARE-CA*CA*VARA)/NDOFI )
C      COMPUTE RMS VALUES
C      NOTE: FOR THIS APPLICATION, RMS = STD.DEV. = SQRT(VARIANCE) .
RMSA = SQRT(VARA/NDOFI)
RMSE = SQRT(VARE/NDOFI)
      RETURN
      END

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      SUBROUTINE CORRTEL(CORREL,NAN,MEX)
C
C      PRINT AN  NAN X MEX  TABLE OF THE ANALYTICAL VS. EXPERIMENTAL
C      CORRELATION COEFFICIENTS.
C
      COMMON /LIMITS/ MAXMODE,MAXDOF
      COMMON /WHEN/ CDATE
      REAL CORREL(MAXMODE,MAXMODE)
      CHARACTER CDATE*9
C
      DO 200 MFIRST=1,MEX,16
      DO 200 NFIRST=1,NAN,50
      MLAST = MIN( MEX, MFIRST+15 )
      NLAST = MIN( NAN, NFIRST+49 )
C      PRINT HEADER FOR ONE PAGE OF THE TABLE
      PRINT 1000, CDATE
      PRINT 2000
      PRINT 3000, (M,M=MFIRST,MLAST)
      DO 100 N=NFIRST,NLAST
      PRINT 4000, N,(CORREL(N,M),M=MFIRST,MLAST)
100      END DO
200      END DO
C
      RETURN
C
1000  FORMAT(1H1,'NASTRAN MODAL ANALYSIS - MODAL SURVEY STATISTICAL ',
      *      'CORRELATION', /1X,A9,
      *      /1H0,'3. CORRELATION COEFFICIENTS FOR ANALYTICAL VS. ',
      *      'EXPERIMENTAL COMPARISONS:')
2000  FORMAT('0ANALYTICAL',24X,'EXPERIMENTAL MODES')
3000  FORMAT(3X,'MODES',3X,I5,15I7)
4000  FORMAT(1X,I6,4X,16(1X,F6.3))
      END
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SUBROUTINE DOFSORT(IDDOF,ICOMP,NDOF,DISP,NMODES)
C
C PUT DOF LIST FOR EACH MODE INTO ASCENDING SORT,
C AND SLAVE-SORT THE CORRESPONDING MODE-SHAPE VECTORS.
C
COMMON /LIMITS/ MAXMODE,MAXDOF
REAL DISP(MAXDOF,MAXMODE)
INTEGER IDDOF(MAXDOF,MAXMODE),ICOMP(MAXDOF,MAXMODE),NDOF(MAXMODE)
C
DO 200 J=1,NMODES
    IF (NDOF(J) .EQ. 1) GOTO 200
DO 100 I=1,NDOF(J)-1
DO 100 K=I+1,NDOF(J)
    IF (IDDOF(K,J) .LT. IDDOF(I,J)) THEN
        CALL SWAP( IDDOF(I,J), IDDOF(K,J) )
        CALL SWAP( ICOMP(I,J), ICOMP(K,J) )
        CALL SWAP( DISP(I,J), DISP(K,J) )
    ELSE IF ((IDDOF(K,J) .EQ. IDDOF(I,J)) .AND.
*          (ICOMP(K,J) .LT. ICOMP(I,J)) ) THEN
        CALL SWAP( IDDOF(I,J), IDDOF(K,J) )
        CALL SWAP( ICOMP(I,J), ICOMP(K,J) )
        CALL SWAP( DISP(I,J), DISP(K,J) )
    END IF
100      CONTINUE
200      CONTINUE
RETURN
END

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SUBROUTINE GETAN(FREQS,MASS,STIFF,ASYMM,SHAPES,NMODES,
*          IDDOF,ICOMPA,NDOFS,LPRINT)
C
C   GET FREQUENCY, MASS, STIFFNESS AND SYMMETRY VECTORS;
C   MODE-SHAPE MATRIX; AND GRID POINT LIST.
C
COMMON /LIMITS/ MAXMODE,MAXDOF
C
REAL FREQS(MAXMODE),MASS(MAXMODE),STIFF(MAXMODE)
REAL SHAPES(MAXDOF,MAXMODE)
INTEGER ASYMM(3,MAXMODE)
INTEGER IDDOF(MAXDOF,MAXMODE),ICOMPA(MAXDOF,MAXMODE)
INTEGER NDOFS(MAXMODE)
CHARACTER*35 FRQFIL,SHPFIL,DOFFIL
CHARACTER*8 FRQMTX,SHPMIX
LOGICAL LPRINT
C
C   GET FILE NAMES
10  TYPE 1000
ACCEPT 2000, FRQFIL
OPEN(UNIT=1,NAME=FRQFIL,TYPE='OLD',READONLY,ERR=10)
IF (LPRINT) PRINT 1500, FRQFIL
20  TYPE 3000
ACCEPT 2000, SHPFIL
OPEN(UNIT=2,NAME=SHPFIL,TYPE='OLD',READONLY,ERR=20)
IF (LPRINT) PRINT 3500, SHPFIL
30  TYPE 4000
ACCEPT 2000, DOFFIL
OPEN(UNIT=3,NAME=DOFFIL,TYPE='OLD',READONLY,ERR=30)
IF (LPRINT) PRINT 4500, DOFFIL
C   READ FREQUENCY FILE
READ(1,7000) FRQMTX,NFREQS,NCOLS
IF (NCOLS .NE. 6) THEN
40  TYPE 5000, FRQMTX,NCOLS
IF (LPRINT) PRINT 5000, FRQMTX,NCOLS
CLOSE(UNIT=1)
CLOSE(UNIT=2)
CLOSE(UNIT=3)
STOP
END IF
IF (NFREQS .GT. MAXMODE) PRINT 6000, NFREQS, MAXMODE
NMODES = MIN(NFREQS,MAXMODE)
DO 100 I=1,6
DO 100 J=1,NFREQS
IF (J .GT. MAXMODE) THEN
READ(1,8000) DUMMY
ELSE IF (I .EQ. 1) THEN | GET FREQUENCY LIST
READ(1,8000) FREQS(J)
ELSE IF (I .EQ. 2) THEN | GET MASS LIST
READ(1,8000) MASS(J)
ELSE IF (I .EQ. 3) THEN | GET STIFFNESS LIST
READ(1,8000) STIFF(J)

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ELSE IF (I .EQ. 4) THEN 1 GET PLANE 1 SYMMETRY LIST
  READ(1,8000) SYMM
  ASYMM(1,J) = NINT(SYMM)
ELSE IF (I .EQ. 5) THEN 1 GET PLANE 2 SYMMETRY LIST
  READ(1,8000) SYMM
  ASYMM(2,J) = NINT(SYMM)
ELSE IF (I .EQ. 6) THEN 1 GET PLANE 3 SYMMETRY LIST
  READ(1,8000) SYMM
  ASYMM(3,J) = NINT(SYMM)
END IF

100      CONTINUE
C      READ MODE-SHAPE FILE
READ(2,7000) SHPMTX,NDISPS,NSHAPES
IF (NSHAPES .NE. NFREQS) THEN
  NMODES = MIN( NFREQS, NSHAPES, NMODES )
  TYPE 9000, NFREQS,NSHAPES,NMODES
  IF (LPRINT) PRINT 9000, NFREQS,NSHAPES,NMODES
END IF
IF (NDISPS .GT. MAXDOF) PRINT 10000, NDISPS,MAXDOF
DO 200 J=1,NMODES
DO 200 I=1,NDISPS
  IF (I .LE. MAXDOF) READ(2,8000) SHAPES(I,J)
  IF (I .GT. MAXDOF) READ(2,8000) DUMMY
200      CONTINUE
C      READ DOF ID FILE
NDOFS(1) = 0
DO 300 I=1,1000000
  IF (I .LE. MAXDOF)
    *      READ(3,11000,END=350) IDDOF(I,1),ICOMPA(I,1)
    IF (I .GT. MAXDOF) READ(3,11000,END=350) IDUMMY,IDUMMC
    NDOFS(1) = NDOFS(1) + 1
300      CONTINUE
350      IF (NDOFS(1) .NE. NDISPS) THEN
      TYPE 12000, NDISPS,NDOFS(1)
      IF (LPRINT) PRINT 12000, NDISPS,NDOFS(1)
      CLOSE(UNIT=1)
      CLOSE(UNIT=2)
      CLOSE(UNIT=3)
      STOP
      ENDIF
NDOFS(1) = MIN(NDOFS(1),MAXDOF)
IF (NMODES .EQ. 1) RETURN
DO 500 J=2,NMODES
  NDOFS(J) = NDOFS(1)
  DO 400 I=1,NDOFS(J)
    IDDOF(I,J) = IDDOF(I,1)
    ICOMPA(I,J) = ICOMPA(I,1)
400      CONTINUE
500      CONTINUE
CLOSE(UNIT=1)
CLOSE(UNIT=2)
CLOSE(UNIT=3)

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      RETURN
C
1000  FORMAT(//, ' ENTER ANALYTICAL LAMA MATRIX FILENAME: ', $)
1500  FORMAT(//, ' ENTER ANALYTICAL LAMA MATRIX FILENAME: ', A35)
2000  FORMAT(A35)
3000  FORMAT(' ENTER ANALYTICAL MODE-SHAPE MATRIX FILENAME: ', $)
3500  FORMAT(' ENTER ANALYTICAL MODE-SHAPE MATRIX FILENAME: ', A35)
4000  FORMAT(' ENTER ANALYTICAL GRID POINT LIST FILENAME: ', $)
4500  FORMAT(' ENTER ANALYTICAL GRID POINT LIST FILENAME: ', A35)
5000  FORMAT(' FREQUENCY MATRIX ', A8, ' HAS ', I6, ' COLUMNS.'
*      ' SHOULD BE 6 COLUMNS.')
6000  FORMAT(' **** WARNING: FREQUENCY VECTOR HAS ', I3, ' ENTRIES.',
*      '/15X, 'ONLY THE FIRST', I5, ' WILL BE USED.')
7000  FORMAT(A8, 2I8)
8000  FORMAT(E16.8)
9000  FORMAT(' **** WARNING: UNEQUAL NUMBER OF FREQUENCIES AND '
*      'MODE SHAPES. ',
*      '/15X, 'NUMBER OF FREQUENCIES:', I6,
*      '/15X, 'NUMBER OF MODE SHAPES:', I6,
*      '/15X, 'ONLY THE FIRST', I5, ' WILL BE USED.')
10000 FORMAT(' **** WARNING: MODE-SHAPE VECTORS HAVE ', I3, ' ENTRIES.',
*      '/15X, 'ONLY THE FIRST', I6, ' WILL BE USED.')
11000 FORMAT(I8, IX, I1)
12000 FORMAT(' **** ERROR: UNEQUAL NUMBER OF MODE-SHAPE POINTS AND ',
*      'D.O.F. ID'S. ', I6, ' _', I6)
      END
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      SUBROUTINE GETEXP(FREQE ,DAMP,ESYMM,DISPEX,MEX,
      *                      IDDOFE,ICOMP,NDOFE,LPRINT)
C
C   GET EXPERIMENTAL FREQUENCY _DAMPING LISTS, MODE-SHAPE MATRIX,
C   AND D.O.F. LIST.
C
      COMMON /LIMITS/ MAXMODE,MAXDOF
C
      REAL FREQEX(MAXMODE),DAMP(MAXMODE),DISPEX(MAXDOF,MAXMODE)
      REAL DUMMY(5)
      INTEGER ESYMM(3,MAXMODE)
      INTEGER IDDOFE(MAXDOF,MAXMODE),ICOMP(MAXDOF,MAXMODE)
      INTEGER NDOFE(MAXMODE)
      CHARACTER*35 MSFILE
      LOGICAL LPRINT
C
C   PROCESS MODE-SHAPE FILES
C   TYPE *, ' ' | SKIP A LINE
      IF (LPRINT) PRINT *, ' '
      MEX = 0
      DO 200 J=1,MAXMODE
C         GET NEXT EXPERIMENTAL MODE-SHAPE FILE
10        TYPE 1000
          ACCEPT 2000, MSFILE
          IF (MSFILE .EQ. 'NONE') GOTO 250
          OPEN(UNIT=10,NAME=MSFILE,TYPE='OLD',READONLY,ERR=10)
          IF (LPRINT) PRINT 1500, MSFILE
C         GET FREQUENCY, DAMPING AND SYMMETRY FOR THIS MODE-SHAPE
          READ(10,*) FREQEX(J)
          READ(10,*) DAMP(J)
          READ(10,*) (ESYMM(K,J),K=1,3)
C         GET MODE-SHAPE DISPLACEMENTS AND D.O.F.'S
          DO 100 I=1,MAXDOF
            READ(10,*,END=150)
              *                      IDDOFE(I,J),ICOMP(I,J),DISPEX(I,J)
              NDOFE(J) = I
100          CONTINUE
          PRINT 5000, MAXDOF,MAXDOF
150          MEX = J
          CLOSE(UNIT=10)
200          CONTINUE
          TYPE 6000, MAXMODE
          IF (LPRINT) PRINT 6000, MAXMODE
250          IF (LPRINT .AND. (MSFILE .EQ. 'NONE')) PRINT 1500, MSFILE
              IF (MEX .EQ. 0) THEN
                TYPE *, ' ***** ERROR: NO EXPERIMENTAL MODE-SHAPE REQUESTS '
                IF (LPRINT) PRINT *,
                  *                      ' ***** ERROR: NO EXPERIMENTAL MODE-SHAPE REQUESTS '
                STOP
              END IF
              RETURN
C

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```

1000  FORMAT(' ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ',
*      ' ("NONE" IF NO MORE) : ', $)
1500  FORMAT(' ENTER NEXT EXPERIMENTAL MODE-SHAPE FILENAME. ',
*      ' ("NONE" IF NO MORE) : ', A35)
2000  FORMAT(A35)
5000  FORMAT(' **** WARNING: MODE-SHAPE VECTOR HAS ', I6, ' OR MORE ',
*          ' ENTRIES. ', /13X, ' ONLY THE FIRST ', I6, ' WILL BE USED. ')
6000  FORMAT(' **** NO MORE EXPERIMENTAL MODE-SHAPE FILES PERMITTED. ',
*          ' MAXIMUM IS ', I4)
      END

```

```

      SUBROUTINE GETVEC(DISP, NDOF, VECT)
C
C      COPY VECTOR OF LENGTH NDOF FROM PERMANENT VECTOR TO
C      WORKING VECTOR.
C
      REAL DISP(*), VECT(*)
C
      IF (NDOF .EQ. 0) RETURN
      DO 100 I=1, NDOF
      VECT(I) = DISP(I)
100    CONTINUE
      RETURN
      END

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SUBROUTINE INPSUM(NAN,FREQAN,MASS,STIFF,ASYMM,
*                MEX,FREQEX,DAMP,          ESYMM)
C
C  PRINT A SUMMARY OF THE ANALYTICAL AND EXPERIMENTAL FREQUENCIES,
C  MASS, STIFFNESS, DAMPING, AND SYMMETRY VECTORS.
C
  REAL FREQAN(*),MASS(*),STIFF(*)
  REAL FREQEX(*),DAMP(*)
  INTEGER ASYMM(3,*),ESYMM(3,*)
  LOGICAL NOSYMA(3),YESYMA(3),NOSYME(3),YESYME(3),FIRST
  CHARACTER CDATE*9
  COMMON /WHEN/ CDATE
  DATA NOSYMA,YESYMA,NOSYME,YESYME/12*.FALSE./, FIRST/.TRUE./
C
C  PRINT HEADER
C  PRINT 8000, CDATE
C  PRINT 1000
C  PRINT ANALYTICAL SUMMARY
C  PRINT ANALYTICAL HEADER
C  PRINT 2000
C  PRINT SUMMARY DATA
  PRINT 3000, (I,FREQAN(I),MASS(I),STIFF(I),
*             (ASYMM(J,I),J=1,3), I=1,NAN)
C  CHECK FOR INCONSISTENT ANALYTICAL "UNDEFINED" SYMMETRY
  DO 200 IAXS=1,3
    DO 100 MODE=1,NAN
      IF (ASYMM(IAXS,MODE).EQ.0) NOSYMA(IAXS)=.TRUE.
      IF (ASYMM(IAXS,MODE).NE.0) YESYMA(IAXS)=.TRUE.
100      CONTINUE
    IF (NOSYMA(IAXS).AND.YESYMA(IAXS)) PRINT 6000, IAXS
200    CONTINUE
C  PRINT EXPERIMENTAL SUMMARY
C  PRINT EXPERIMENTAL HEADER
C  PRINT 4000
C  PRINT SUMMARY DATA
  PRINT 5000, (I,FREQEX(I),DAMP(I),
*             (ESYMM(J,I),J=1,3), I=1,MEX)
C  CHECK FOR INCONSISTENT EXPERIMENTAL "UNDEFINED" SYMMETRY
  DO 400 IAXS=1,3
    DO 300 MODE=1,MEX
      IF (ESYMM(IAXS,MODE).EQ.0) NOSYME(IAXS)=.TRUE.
      IF (ESYMM(IAXS,MODE).NE.0) YESYME(IAXS)=.TRUE.
300      CONTINUE
    IF (NOSYME(IAXS).AND.YESYME(IAXS)) PRINT 6000, IAXS
400    CONTINUE
C  CHECK FOR INCONSISTENT ANA VS. EXP "UNDEFINED" SYMMETRY
  DO 500 IAXS=1,3
    IF ( (NOSYMA(IAXS).AND.YESYME(IAXS)) .OR.
*       (YESYMA(IAXS).AND.NOSYME(IAXS)) ) THEN
      IF (FIRST) PRINT 7000
      FIRST = .FALSE.
      PRINT 6000, IAXS
    
```

```

      END IF
500    CONTINUE
      RETURN
C
1000  FORMAT(1H0,'2. SUMMARY OF FREQUENCY, MASS, STIFFNESS,',
*      ' DAMPING, AND SYMMETRY:')
2000  FORMAT(//,5X,'ANALYTICAL MODES:')
*      /1H0,4X,'MODE ',,      FREQUENCY      ',,      MASS      ',
*      ' STIFFNESS      ',,      SYMMETRY      ',
*      /,5X,'_',4(1X,'_'))
3000  FORMAT(<NAN>(/5X,I3,1X,3(1PE16.8),3X,3I3),/)
4000  FORMAT(//,5X,'EXPERIMENTAL MODES:')
*      /1H0,4X,'MODE FREQUENCY  DAMPING  SYMMETRY',
*      /,5X,'_',3(1X,'_'))
5000  FORMAT(<MEX>(/5X,I3,1X,2(1PE11.3),1X,3I3),/)
6000  FORMAT(10X,'***WARNING: INCONSISTENT UNDEFINED SYMMETRY',
*      ' FOR PLANE',I2)
7000  FORMAT(//,5X,'ANALYTICAL VS. EXPERIMENTAL SYMMETRY:')
8000  FORMAT(1H1,'NASTRAN MODAL ANALYSIS - MODAL SURVEY STATISTICAL ',
*      'CORRELATION', /1X,A9)
      END

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SUBROUTINE INTERSECT(AVECT,EVECT,IDDOFA,IDDOFE,ICOMPA,ICOMPE,
*                      NDOFA,NDOFE,IDDOFI,ICOMPI,NDOFI,
*                      ASYMM,ESYMM,LSYMM)
C
C   COPY INTERSECTION SET OF VECTORS IDDOFA AND IDDOFE TO VECTOR
C   IDDOFI.  NDOFI IS THE LENGTH OF THE INTERSECTION SET.
C   REDUCE AVECT AND EVECT VECTORS TO CONTAIN ONLY THE CORRESPONDING
C   INTERSECTION SET OF TERMS, I.A.W. THE MASTER SET IDDOFI.
C   IF THE INTERSECTION SET IS NULL (NO EQUIVALENT D.O.F ID'S),
C   THE VALUE RETURNED FOR NDOFI IS 0 .
C   IF SYMMETRY IS TO BE CONSIDERED, AND ANALYTICAL AND EXPERIMENTAL
C   SYMMETRY ARE NOT THE SAME, THE VALUE RETURNED FOR NDOFI IS 0 .
C
REAL AVECT(*),EVECT(*)
INTEGER IDDOFA(*),IDDOFE(*),IDDOFI(*)
INTEGER ICOMPA(*),ICOMPE(*),ICOMPI(*)
INTEGER ASYMM(3),ESYMM(3)
LOGICAL LSYMM
C
IA = 1
IE = 1
NDOFI = 0
IF (LSYMM) THEN
C   SYMMETRY IS TO BE CONSIDERED:
C   IF A AND E ARE UNLIKE, LEAVE INTERSECTION SET AS NULL
  IF (ASYMM(1) .NE. ESYMM(1)) RETURN
  IF (ASYMM(2) .NE. ESYMM(2)) RETURN
  IF (ASYMM(3) .NE. ESYMM(3)) RETURN
END IF
C
DO 100 I=1,NDOFA+NDOFE
IF ((IA.GT.NDOFA) .OR. (IE.GT.NDOFE)) GOTO 150
IF ( (IDDOFA(IA) .EQ. IDDOFE(IE)) .AND.
*   (ICOMPA(IA) .EQ. ICOMPE(IE)) ) THEN
  NDOFI = NDOFI + 1
  IDDOFI(NDOFI) = IDDOFA(IA)
  ICOMPI(NDOFI) = ICOMPA(IA)
  AVECT(NDOFI) = AVECT(IA)
  EVECT(NDOFI) = EVECT(IE)
  IA = IA + 1
  IE = IE + 1
ELSE IF (IDDOFA(IA) .LT. IDDOFE(IE)) THEN
  IA = IA + 1
ELSE IF (IDDOFE(IE) .LT. IDDOFA(IA)) THEN
  IE = IE + 1
END IF
100 CONTINUE
150 RETURN
END

```

```

C      SUBROUTINE MATCH(CORREL,NAN,MEX,NAFIT,MEFIT)
C
C      COMMON /LIMITS/ MAXMODE,MAXDOF
C
C      DIMENSION CORREL(MAXMODE,MAXMODE),NAFIT(MAXMODE),MEFIT(MAXMODE)
C
C      DETERMINE BEST EXPERIMENTAL MODE-SHAPE MATCH (HIGHEST
C      CORRELATION COEFFICIENT) FOR EACH ANALYTICAL MODE-SHAPE.
C
DO 200 N=1,NAN
    BEST = -1.0
    DO 100 M=1,MEX
        IF (ABS(CORREL(N,M)) .GT. BEST) THEN
            BEST = ABS(CORREL(N,M))
            NAFIT(N) = M
        END IF
100        CONTINUE
200        CONTINUE
C
C      DETERMINE BEST ANALYTICAL MODE-SHAPE MATCH (HIGHEST
C      CORRELATION COEFFICIENT) FOR EACH EXPERIMENTAL MODE-SHAPE.
C
DO 400 M=1,MEX
    BEST = -1.0
    DO 300 N=1,NAN
        IF (ABS(CORREL(N,M)) .GT. BEST) THEN
            BEST = ABS(CORREL(N,M))
            MEFIT(M) = N
        END IF
300        CONTINUE
400        CONTINUE
C
RETURN
END

```

```

SUBROUTINE OPTIONS(LSYMM,PR TAN,PRTEX,RTHRESH,LPRINT)
C
C   DETERMINE SYMMETRY, MODE-SHAPE DUMP, AND THRESHOLD OPTIONS
C   LOGICAL LS YMM,PR TAN,PRTEX,LPRINT
C   CHARACTER*1 YESNO
C   DETERMINE IF SYMMETRY IS TO BE CONSIDERED
TYPE 1000
ACCEPT 2000, YESNO
IF (YESNO.EQ. 'Y') LS YMM = .TRUE.
IF (LPRINT) PRINT 1500, YESNO
C   DETERMINE IF ANALYTICAL AND/OR EXPERIMENTAL MODE-SHAPE
C   VECTORS ARE TO BE PRINTED
TYPE *, ' ' |SKIP A LINE
IF (LPRINT) PRINT *, ' '
TYPE 3000, 'ANALYTICAL'
ACCEPT 2000, YESNO
IF (YESNO.EQ. 'Y') PR TAN = .TRUE.
IF (LPRINT) PRINT 3500, 'ANALYTICAL', YESNO
TYPE 3000, 'EXPERIMENTAL'
ACCEPT 2000, YESNO
IF (YESNO.EQ. 'Y') PR TEX = .TRUE.
IF (LPRINT) PRINT 3500, 'EXPERIMENTAL', YESNO
C   GET RELATIVE DEVIATION THRESHOLD. DEFAULT IS 5.0 %
RTHRESH = .05
TYPE 4000, RTHRESH
ACCEPT *, RTHRESH
TYPE 5000, RTHRESH
IF (LPRINT) THEN
PRINT 4500, .05, RTHRESH
PRINT 5000, RTHRESH
END IF
RETURN
C
1000 FORMAT(/, ' IS ANALYTICAL VS. EXPERIMENTAL SYMMETRY TO BE ',
* 'CONSIDERED? (Y OR N): ', $)
1500 FORMAT(/, ' IS ANALYTICAL VS. EXPERIMENTAL SYMMETRY TO BE ',
* 'CONSIDERED? (Y OR N): ', A1)
2000 FORMAT(A1)
3000 FORMAT(' PRINT ', A12, ' MODE-SHAPE VECTORS? (Y OR N): ', $)
3500 FORMAT(' PRINT ', A12, ' MODE-SHAPE VECTORS? (Y OR N): ', A1)
4000 FORMAT(/, ' RELATIVE DEVIATIONS GREATER THAN A THRESHOLD',
* ' VALUE WILL BE PRINTED.',
* // ' THE DEFAULT THRESHOLD IS ', F6.3,
* // ' ENTER DESIRED THRESHOLD. ", " FOR DEFAULT: ', $)
4500 FORMAT(/, ' RELATIVE DEVIATIONS GREATER THAN A THRESHOLD',
* ' VALUE WILL BE PRINTED.',
* // ' THE DEFAULT THRESHOLD IS ', F6.3,
* // ' ENTER DESIRED THRESHOLD. ", " FOR DEFAULT: ', F6.3)
5000 FORMAT(' RELATIVE DEVIATIONS GREATER THAN ', 2PF7.2,
* ' % WILL BE PRINTED.')
END

```

```

SUBROUTINE PRINT(N1,FREQ1,N2,FREQ2,NDOF,CORREL,C,S,RMSA,RMSE,
*          DIFF,DIFABS,IDDOF,ICOMP,RTHRESH)
C
C   PRINT CORRELATION INFORMATION FOR MODES N1,N2 COMPARISON
C
C   DIMENSION DIFF(*),DIFABS(*),IDDOF(*),ICOMP(*)
C   DIMENSION ID(30000)
C
C   DETERMINE MAXIMUM DIFFERENCE AND DIFFS > THRESHOLD
DIFMAX = 0.0
IDMAX = 0
NDIFF = 0
IF (NDOF .GT. 0) THEN
  DIFMAX = ABS(DIFF(1))
  IDMAX = IDDOF(1)
  DO 100 N=1,NDOF
    IF (ABS(DIFF(N)) .GT. DIFMAX) THEN
      DIFMAX = ABS(DIFF(N))
      IDMAX = IDDOF(N)
    END IF
    IF (ABS(DIFF(N)) .GT. RTHRESH) THEN
      NDIFF = NDIFF + 1
      ID(NDIFF) = N
    END IF
100    CONTINUE
  END IF
C
C   PRINT SUMMARY LINE FOR THIS MATCHED PAIR
PRINT 1000, N1,FREQ1,N2,FREQ2,NDOF,CORREL,C,S,
*          RMSA,RMSE,DIFMAX,IDMAX
IF (NDOF .EQ. 0) RETURN
C
C   PRINT ALL DIFFS > THRESHOLD , DEFAULT IS 5%
IF (NDIFF .GT. 0) THEN
  PRINT 2000, RTHRESH,(IDDOF(ID(N)), ICOMP(ID(N)),
*          DIFF(ID(N)), N=1,NDIFF)
  PRINT 3000, (IDDOF(ID(N)), ICOMP(ID(N)), DIFABS(ID(N)),
*          N=1,NDIFF)
  END IF
RETURN
C
1000 FORMAT('0',I6,2(F15.6,I7),4X,F9.3,2X,5(1PE11.3),I9)
2000 FORMAT(21X,'RELATIVE DEVIATIONS (XA/RMSA-XE/RMSE) > ',
*          2PF7.2,'% : (GRID ID/DEVIATION)',
*          20(/21X,5(I9,'-',I1,'/',1PE10.3)))
3000 FORMAT(21X,'SCALED DIFFERENCES ( (XA-XE)/S ) > THRESHOLD :',
*          '(GRID ID/DIFFERENCE)',
*          20(/21X,5(I9,'-',I1,'/',1PE10.3)))
END

```

```

SUBROUTINE PRINTPHI(NAN,NDOFA,IDDOFA,ICOMPA,DISPAN,PRTAN,
*                      MEX,NDOFE,IDDOFE,ICOMPE,DISPEX,PRTEX)
C
COMMON /LIMITS/ MAXMODE,MAXDOF
COMMON /WHEN/ CDATE
C
REAL DISPAN(MAXDOF,MAXMODE),DISPEX(MAXDOF,MAXMODE)
INTEGER IDDOFA(MAXDOF,MAXMODE), IDDOFE(MAXDOF,MAXMODE)
INTEGER ICOMPA(MAXDOF,MAXMODE), ICOMPE(MAXDOF,MAXMODE)
INTEGER NDOFA(MAXMODE), NDOFE(MAXMODE)
LOGICAL PRTAN,PRTEX
CHARACTER CDATE*9
C
IF (PRTAN) THEN | PRINT ANALYTICAL MODE-SHAPE VECTORS
C
PRINT HEADER
PRINT 5000, CDATE
PRINT 1000
C
PRINT ALL VECTORS
DO 100 I=1,NAN
PRINT 2000, I,(IDDOFA(J,I),ICOMPA(J,I),DISPAN(J,I),
*                      J=1,NDOFA(I))
100
CONTINUE
END IF
C
IF (PRTEX) THEN | PRINT EXPERIMENTAL MODE-SHAPE VECTORS
C
PRINT HEADER
PRINT 5000, CDATE
PRINT 3000
C
PRINT ALL VECTORS
DO 200 I=1,MEX
PRINT 4000, I,(IDDOFE(J,I),ICOMPE(J,I),DISPEX(J,I),
*                      J=1,NDOFE(I))
200
CONTINUE
END IF
RETURN
C
1000 FORMAT(1H0,'6. ANALYTICAL MODE-SHAPE VECTORS ',
*          '(GRID PT/DISPLACEMENT)')
2000 FORMAT(1H0,'ANALYTICAL MODE',I4,
*          200(/5X,5(I9,'-',I1,'/',1PE10.3)))
3000 FORMAT(1H0,'7. EXPERIMENTAL MODE-SHAPE VECTORS ',
*          '(GRID PT/DISPLACEMENT)')
4000 FORMAT(1H0,'EXPERIMENTAL MODE',I4,
*          200(/5X,5(I9,'-',I1,'/',1PE10.3)))
5000 FORMAT(1H1,'NASTRAN MODAL ANALYSIS - MODAL SURVEY STATISTICAL ',
*          'CORRELATION', /1X,A9)
END

```

```

      SUBROUTINE RMSDIFF(AVECT,EVECT,NDOFI,RMSA,RMSE,CORREL,
      *                   S,DIFF,DIFABS)
C
C      CALCULATE RELATIVE (TO RMS) DIFFERENCE BETWEEN ANALYTICAL AND
C      EXPERIMENTAL DISPLACEMENT FOR EACH GRID POINT.
C      CALCULATE ABSOLUTE DIFFERENCE SCALED TO ANALYTICAL.
C
      REAL AVECT(*),EVECT(*),DIFF(*),DIFABS(*)
C
      IF (NDOFI .EQ. 0) RETURN
      DO 100 I=1,NDOFI
      IF (CORREL .GE. 0.0) THEN
        DIFF(I) = 0.0
        IF ( (RMSA .NE. 0.0) .AND. (RMSE .NE. 0.0) )
          *      DIFF(I) = AVECT(I)/RMSA - EVECT(I)/RMSE
        DIFABS(I) = 0.0
        IF (S .NE. 0.0)
          *      DIFABS(I) = (AVECT(I) - EVECT(I)) / S
      ELSE IF (CORREL .LT. 0.0) THEN
C      CORRECT FOR 180-DEGREE PHASE SHIFT
        DIFF(I) = 0.0
        IF ( (RMSA .NE. 0.0) .AND. (RMSE .NE. 0.0) )
          *      DIFF(I) = AVECT(I)/RMSA + EVECT(I)/RMSE
        DIFABS(I) = 0.0
        IF (S .NE. 0.0)
          *      DIFABS(I) = (AVECT(I) + EVECT(I)) / S
      END IF
100    CONTINUE
      RETURN
      END

```

```

      SUBROUTINE SWAP(I,J)
C
C      INTERCHANGE THE VALUES IN TWO 4-BYTE VARIABLES
C
      ITEM = I
      I = J
      J = ITEM
      RETURN
      END

```